Materials in Design Engineering

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MATERIALS
& METHODS

SELECTION & USE OF METALS, NONMETALLICS, FORMS, FINISHES

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Materials for Gears—Manual No. 143

Hot Extruded Steel Shapes

Cross-Creped Kraft—A New Kind of Paper

Three Manganese Alloys

Titanium Plating

Designing for Compression Moldings

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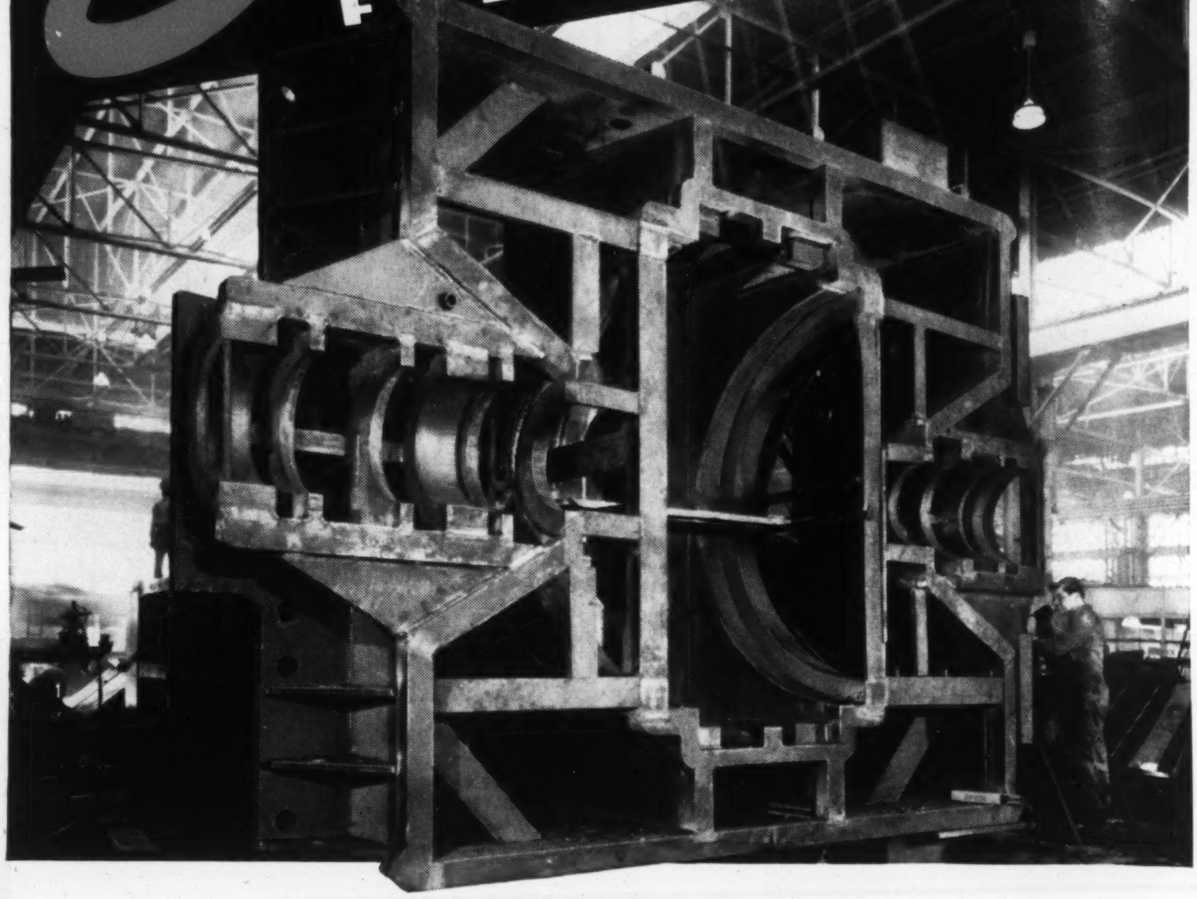
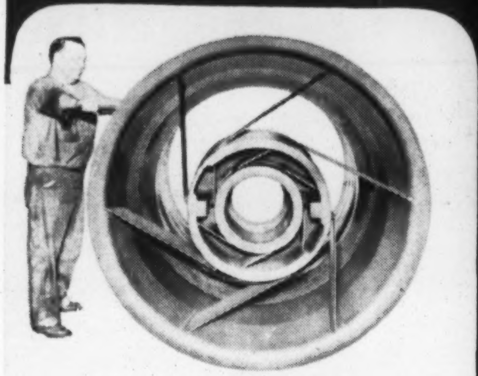
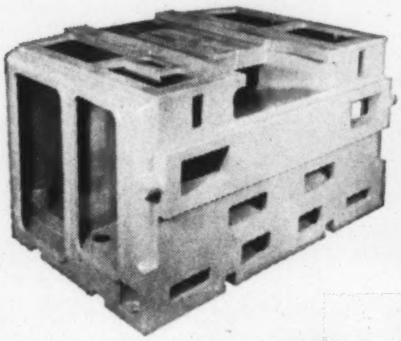
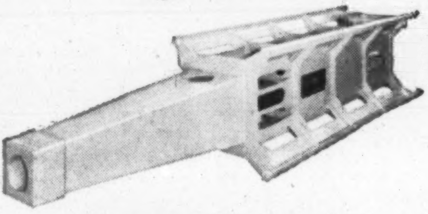
PRICE ONE DOLLAR

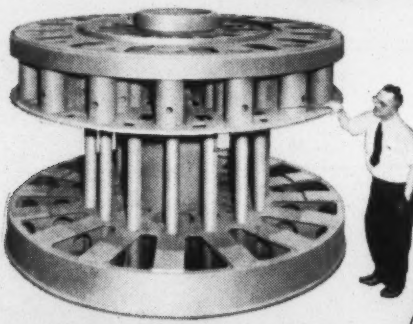
Steel-Weld FABRICATION

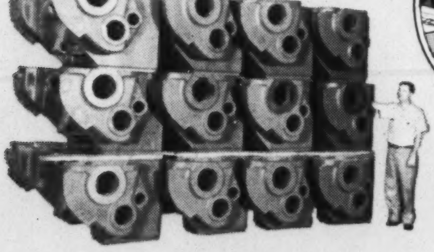


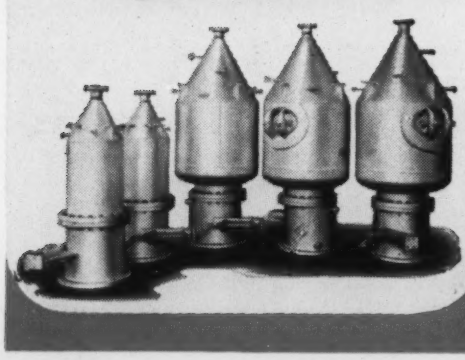












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This periodical is indexed regularly in the Engineering Index and the Industrial Arts Index

Materials in Design Engineering

formerly Materials & Methods

Selection & use of metals, nonmetallics, forms, finishes

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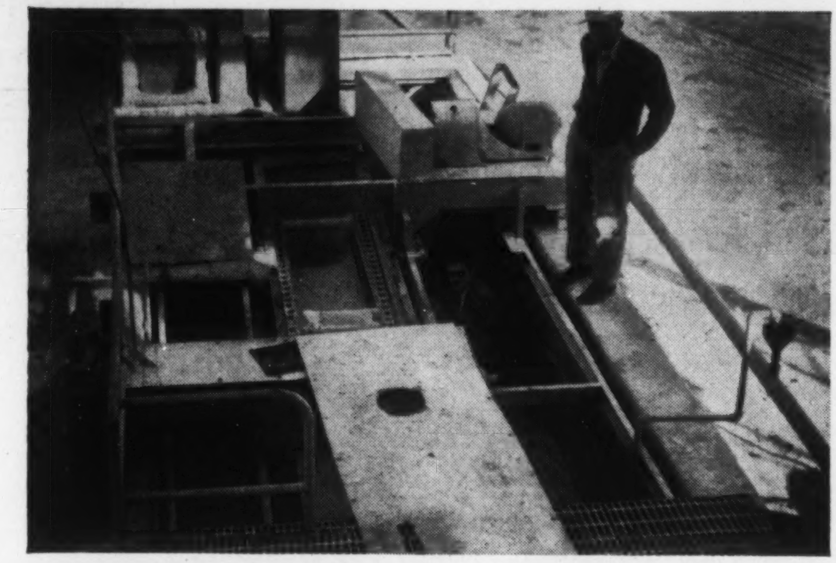
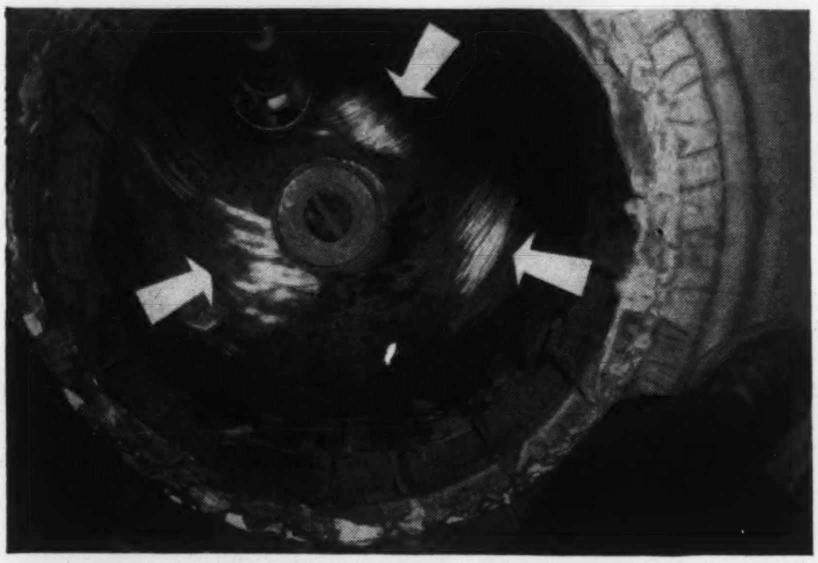
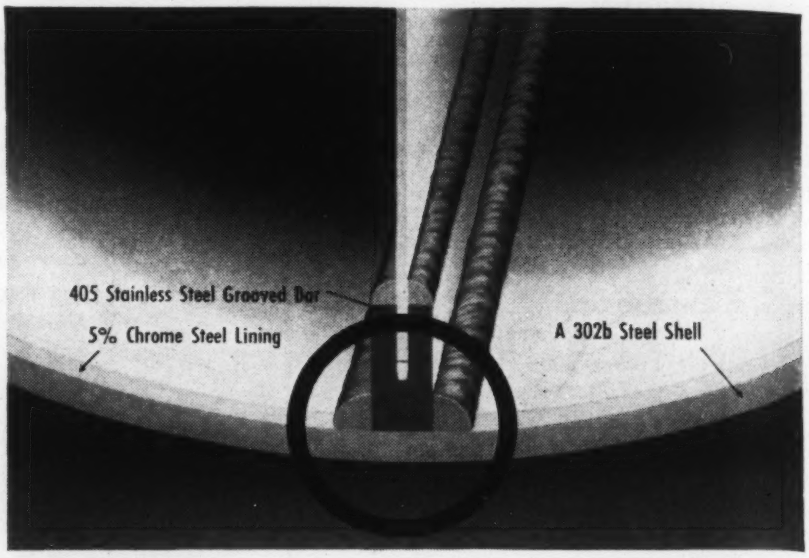


Weld: 304 stainless to mild steel
Conditions: chloride corrosion **Equipment:** drag conveyor

Weld: Inconel* nickel-chromium alloy to ordinary steel
Conditions: high temperature **Equipment:** furnace retort



Weld: repair of cracks in carbon-molybdenum steel
Conditions: no preheat possible **Equipment:** throttle valve



Weld: 405 stainless to 5% chrome steel and A302-B steel
Conditions: high pressure **Equipment:** pressure vessel

Now one electrode, Inco-Rod "A", ...permits new design freedom

No longer need difficulty in welding dissimilar alloys limit design possibilities.

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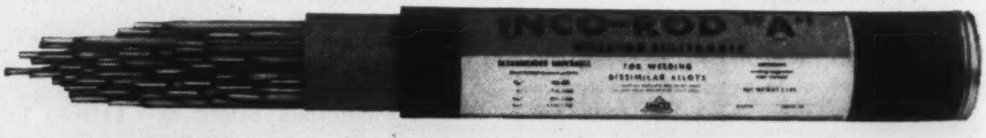

Inco-Rod "A" electrode is supplied in four diameters: 3/32-, 1/8-, 5/32-, and 3/16-inch . . . packed in 5-lb. asphalt-lined containers.

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What's new IN MATERIALS

...AT A GLANCE

STRONG BONDS BETWEEN STEEL AND STEEL WITHIN 15 SEC are possible with a new, room temperature curing, uncatalyzed, liquid adhesive. Tests show that the adhesive, a modified cyanoacrylate monomer, can bond rubber, plastics, ferrous and nonferrous metals and wood to each other and to other materials within minutes. The adhesive is currently available in limited quantities for test purposes. (More details next month.)

A NEW, LITHIUM TYPE ALUMINUM ALLOY is reported to maintain high strength at temperatures up to 400 F; conventional aluminum alloys generally lose their strength at temperatures around 300 F. According to the producer, the lithium content of the alloy improves the metal's ductility by some 8% over that of standard aluminum alloys. The new metal was developed specifically for high speed aircraft parts and shapes. (More details next month.)

ANOTHER ALUMINUM ALLOY, an aluminium-silicon-manganese-magnesium composition, is being used as a barrel in a newly developed automatic rifle. The alloy is said to have a tensile strength in excess of 100,000 psi and a yield strength of 90,000 psi. The aluminum barreled rifle is capable of firing 600 rounds per min.

A RELATIVELY NEW THERMOPLASTIC, isotactic polypropylene, is now in commercial production in Italy and will be available in this country next year in the form of sterilizable opaque and translucent household and industrial products. The thermoplastic, made by a low pressure process, is said to withstand temperatures over 300 F. (A preview of the plastic will appear in next month's issue.)

STRONGER ALUMINUM AND MAGNESIUM CASTINGS are possible by "press-forging" them at various temperatures. Tests conducted on "forged" aluminum castings show they have better yield and ultimate strength properties, but lower elongation, than unforged aluminum castings. The same improvement takes place in forged magnesium castings, but the strength of titanium castings is only slightly increased by press-forging.

MAN-MADE INDUSTRIAL DIAMONDS, first developed about two years ago, will soon be commercially available. The diamonds, said to be equal in hardness to natural diamonds, are made by subjecting carbonaceous materials to extremely high pressures and temperatures. The current price of man-made diamonds is slightly above the price of natural diamonds.

CARBON WOOL, resembling steel or glass wool, is claimed to withstand temperatures of 5000 F or more under certain conditions. According to the producer, the product is a dense fibrous form of pure carbon that can be woven into cloth. The material is recommended as a filtering medium and as an insulation. It is supplied in either an activated or inert form.

PRESSURE SENSITIVE SILICONE RUBBER TAPES, made of "fusible" silicone rubbers, are said to have "built-in" adhesive properties. The rubber tapes—a general purpose insulating type and an electrical conducting type—do not lose their hardness when exposed to high temperatures, according to the producer. The tapes are expected to find use as insulating materials in both military and commercial applications. (More details next month.)

HEAT RESISTANT EPOXY ADHESIVES for bonding stainless steel to itself and to other materials are said to withstand continuous exposure at temperatures up to 500 F. Laboratory tests show the adhesives have lap shear strengths of 1500 psi after 10 min aging at 455 F and 800 psi after 400 hr at 455 F. According to the producer, the adhesives are readily adaptable to presently used bonding techniques and are recommended particularly for stainless steel honeycomb sandwich constructions. (More details next month.)

A NEW LITHIUM TYPE CERAMIC COATING has been applied successfully to aluminum aircraft structures. Previous attempts to coat these structures have resulted in blistering, bubbling, brittleness and excessive warpage of the coating. The coated aluminum, said to withstand prolonged heat of 1300 to 1350 F, can be bent, drilled, punched and sheared. (More details next month.)

A HIGH DENSITY POLYETHYLENE RESIN is now available in four different types for easier design of plastics parts. Key to classification of the new resins is melt index which indicates what kind of flow, impact strength and stress cracking resistance the resin will have. Density, tensile strength and hardness are the same for all four types.

ACRYLATE TYPE SYNTHETIC RUBBER COMPOUNDS seem to offer the best resistance to silicate ester fluids at high temperatures, recent research shows. This type of polymer did not crack after oil aging for 500 hr at 400 F, whereas other polymers crack after 200 hr aging. The compounds maintain 400 to 500% elongation after aging.

Turn to page 173 for more "What's New in Materials"

MATERIALS BRIEFS

In the Bag

Polyethylene bags are used to maintain an inert gas atmosphere in the welding of titanium aircraft parts. The plastics bag allows titanium to be heated at welding temperatures without contaminating the metal.

Tanked-Up

Vacuum sealed, stainless steel tanks are used aboard a cargo ship that transports 650,000 gal of orange juice from Florida to New York in six days. During the ship's run the temperature of the orange juice is maintained at 28-30 F.

Dead Ducks Don't Sink

A decoy duck having a polyethylene shell and a core of urethane foam has been deliberately shot full of holes without affecting its buoyancy. The finished decoy weighs under 1½ lb.

Moon over Moscow

In addition to their recent efforts, Russian scientists expect to launch an aluminum sphere that will shine more brightly than a star of the first magnitude. The sphere is 25 in. in dia and weighs approximately 22 lb when filled with instruments.

Spotless Meals

A colorless liquid derived by electrolysis from fluorspar rock is said to make certain fabrics and suede leathers repellent to oils, water, salad dressing, milk and ink. The stain repellent compound, now being tested in men's clothing and furniture fabrics, lasts through at least five dry cleanings.

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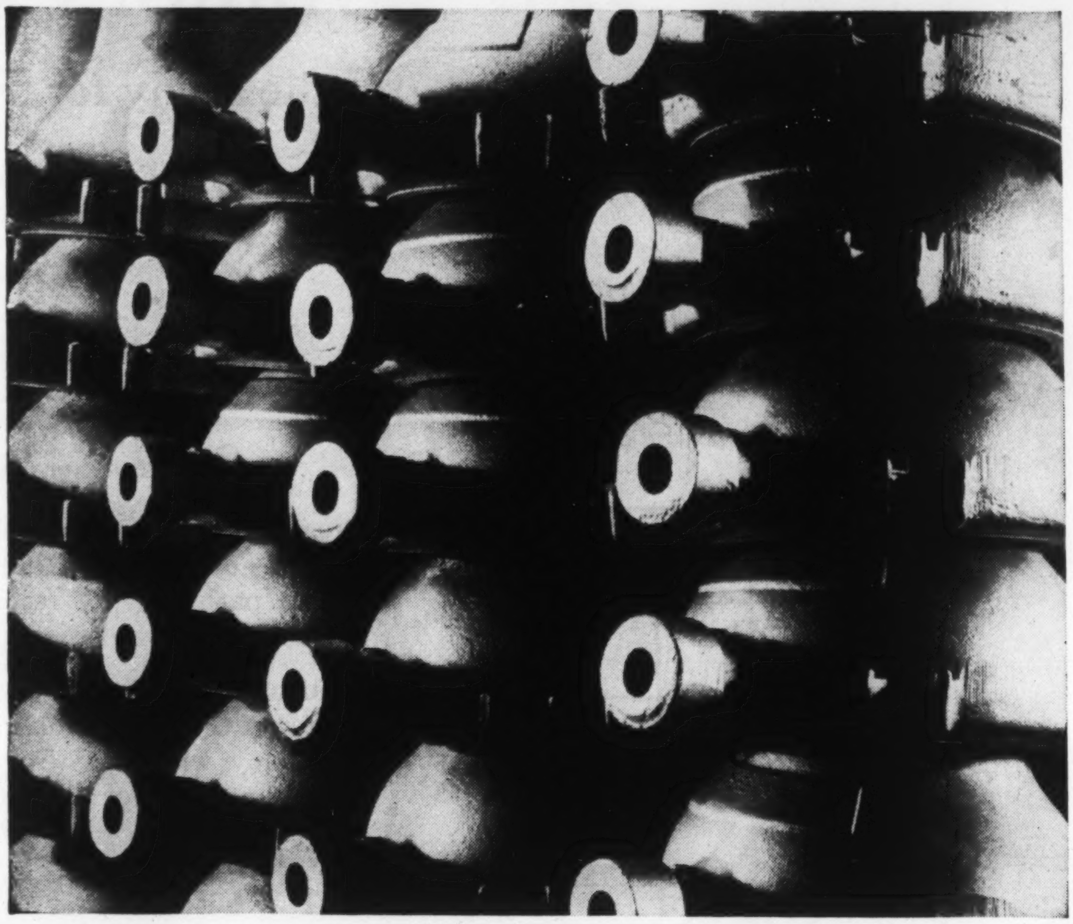

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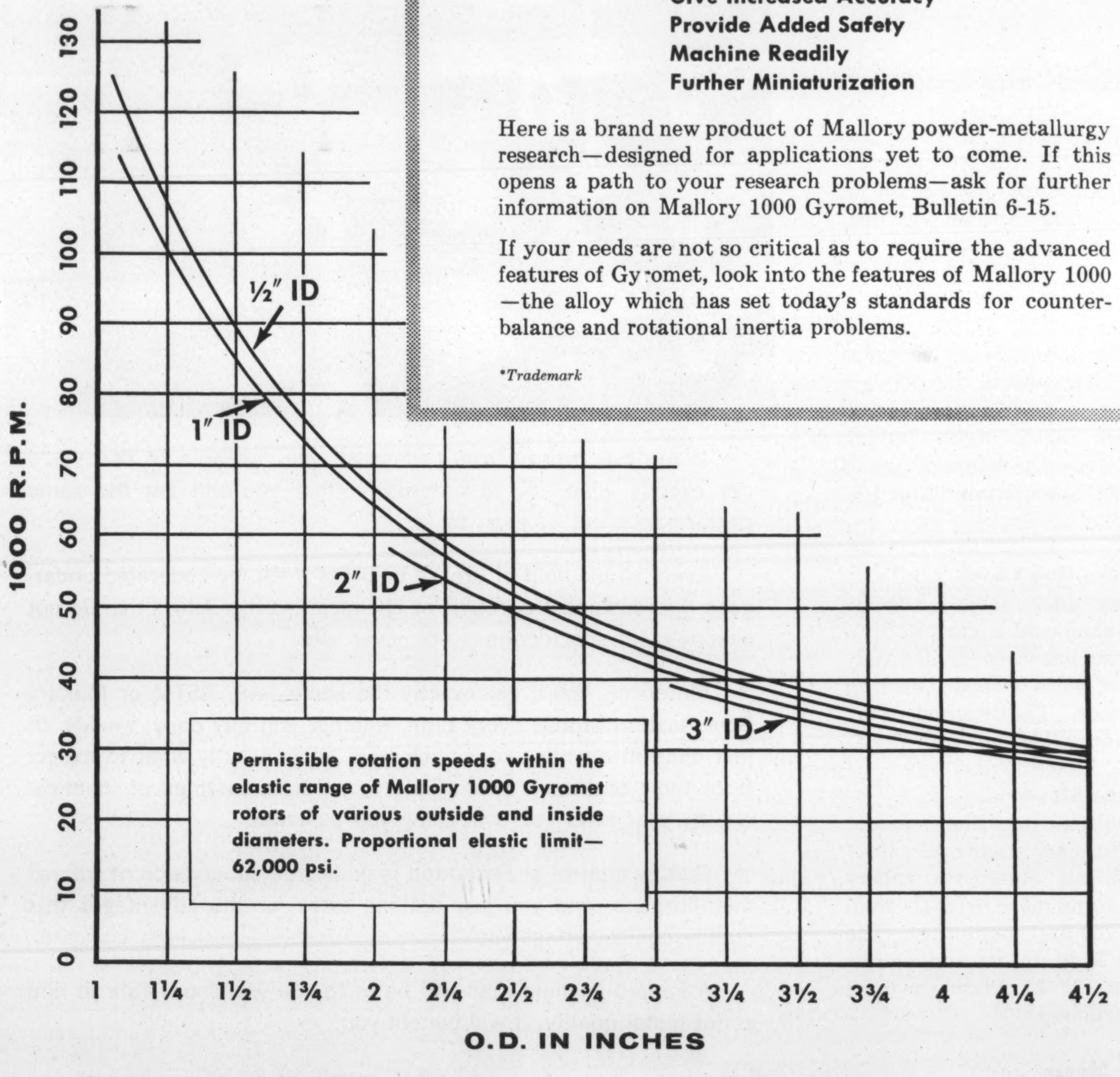

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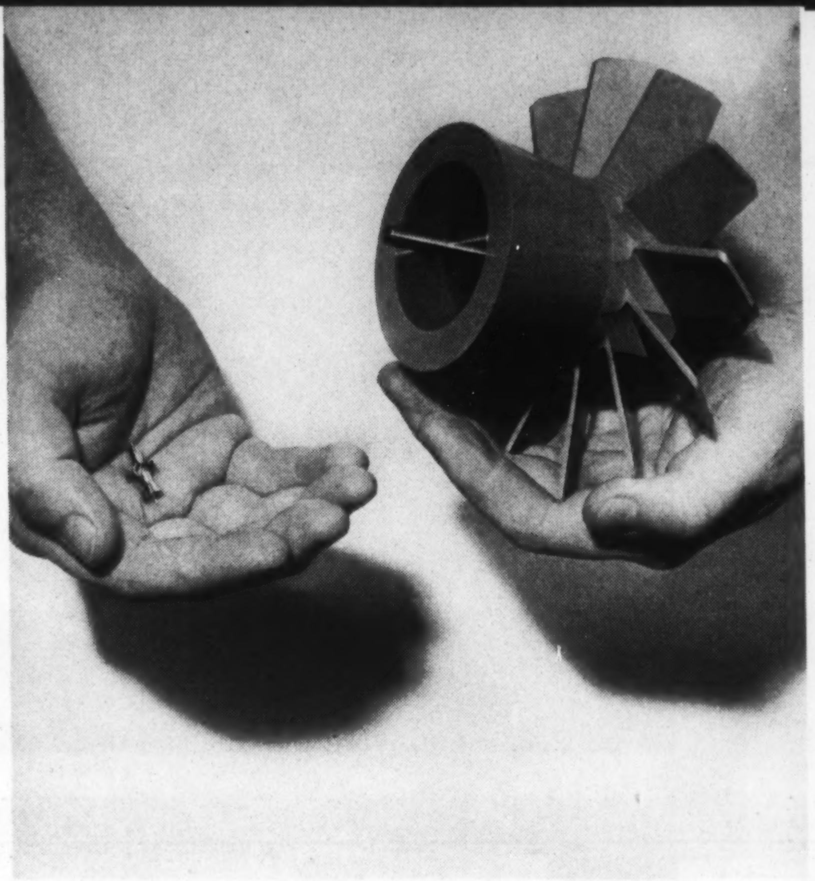
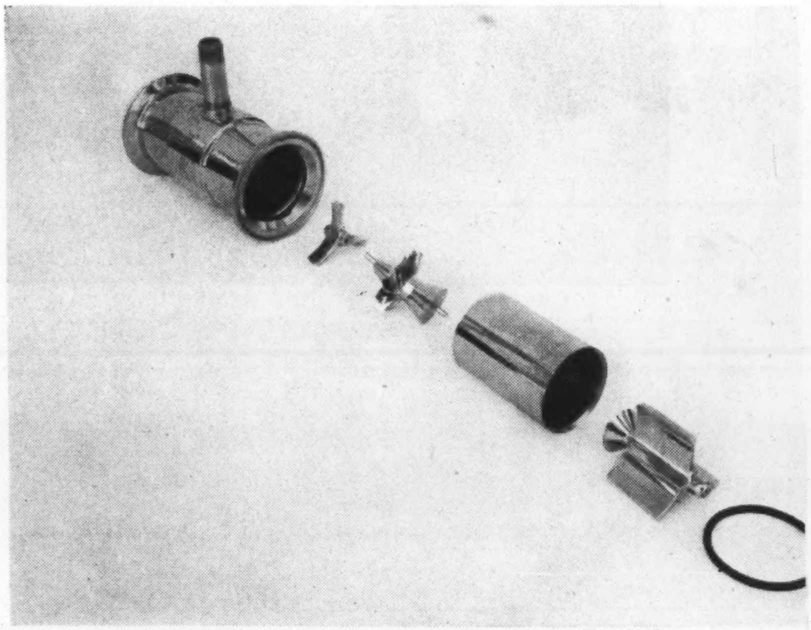
MATERIALS AT WORK

New and interesting applications of engineering materials



***Stainless steel rotors,** available in diameters ranging from ⅛ to 12 in., are specified for . . .*



Carpenter Steel Co.

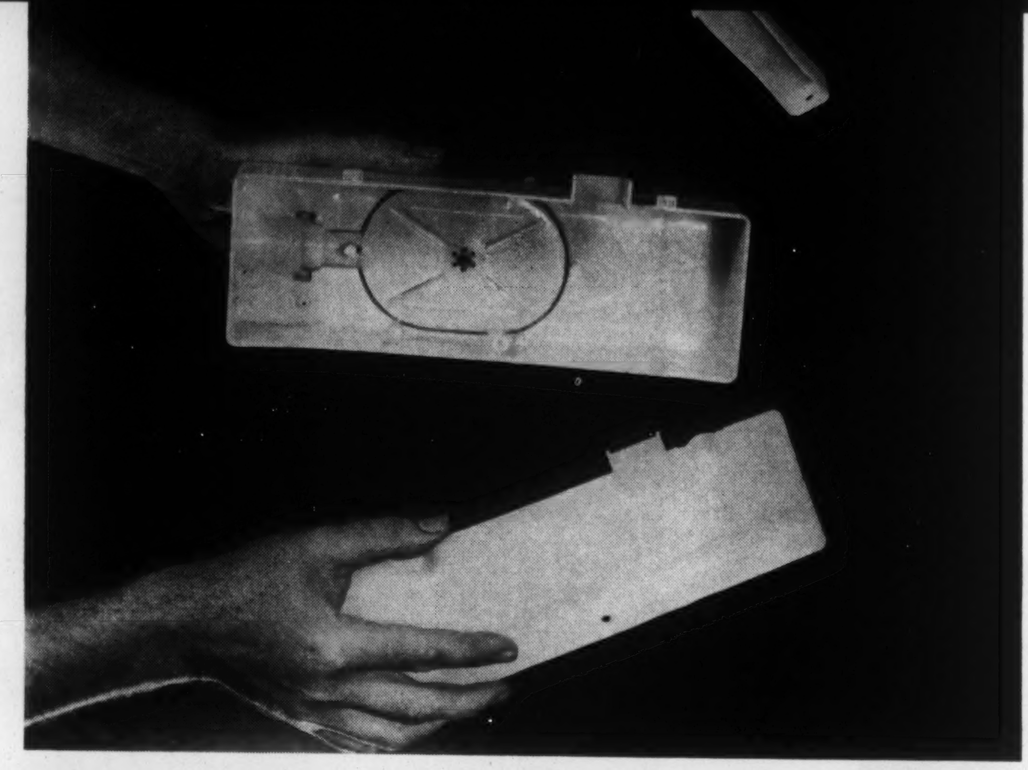
*. . . **flow sensing meters** used to measure corrosive fluids over wide temperature range.*

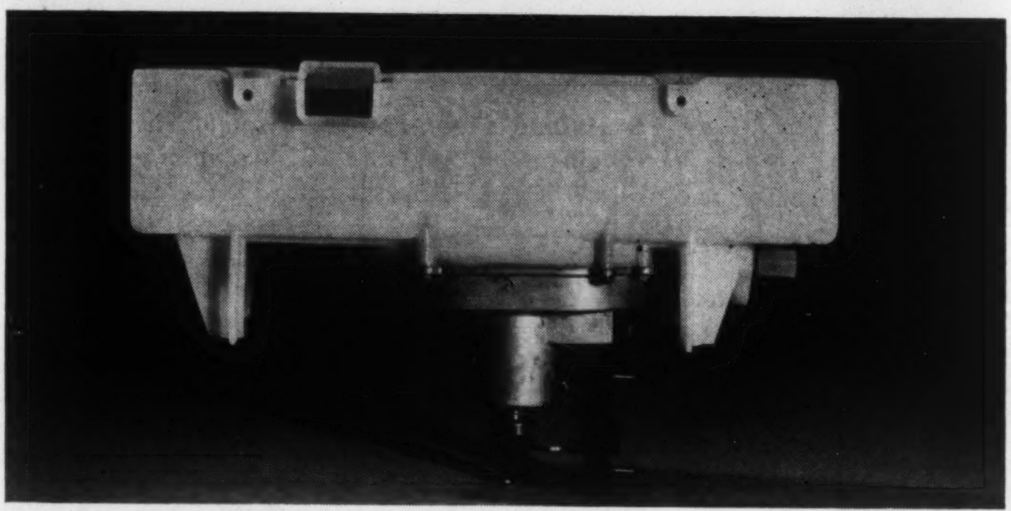
Stainless prevents corrosion in precision flow meter

A special grade of stainless steel (Carpenter 20) has eliminated the problem of corrosion in the precision flow sensing meters made by Potter Aeronautical Corp.

The flow meter, a bearingless, turbine-type unit, is used in rocket, guided missile and jet engine fuel systems, as well as in the chemical and food processing industries. It is used to measure fluids at temperatures ranging from —455 to + 1200 F. and pressures of 35,000 psi and higher.

The excellent machinability and corrosion resistance of the special steel are given as reasons for its selection.





Hercules Powder Co.

Dispensing unit uses linear polyethylene

One of the latest applications of the new high density (low pressure) polyethylene is the liquid fabric conditioner dispensing unit shown at the left. The unit, manufactured by Dole Valve Co., incorporates three molded polyethylene components: body, lid and spout (see top photo).

In addition to providing advantages common to conventional polyethylene, the new material is less permeable to gases and vapors, more resistant to environmental stress cracking, and somewhat less affected by organic solvents and chemical reagents. Moreover, the new polyethylene can be sterilized in boiling water and possesses higher density and tensile strength.

Empire Steel Castings, Inc.

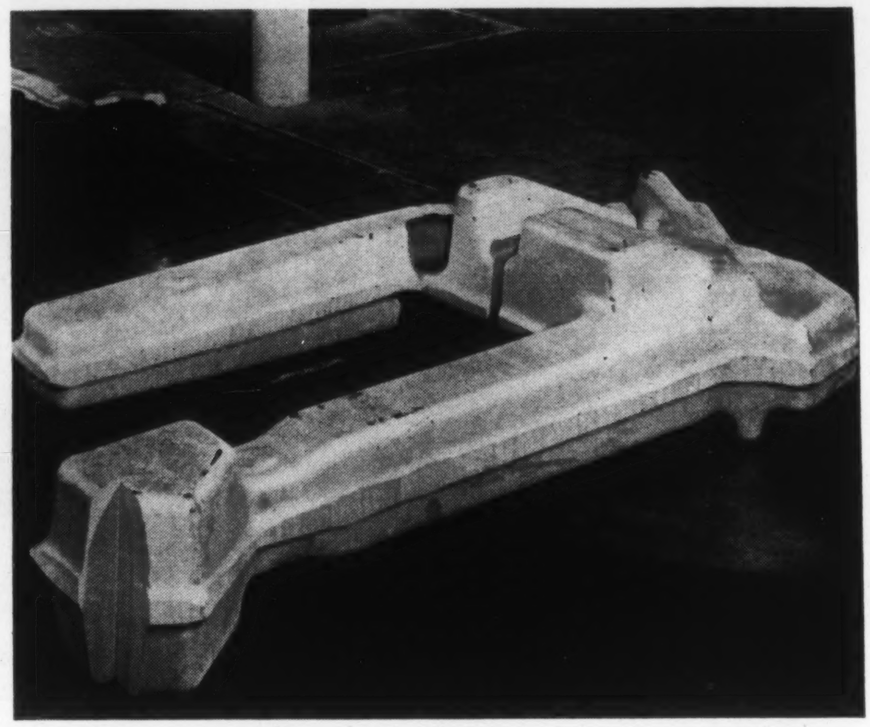
Cast stainless screw cuts machining costs

By designing an unusually large screw that can be cast rather than machined from bar stock, a manufacturer of food processing equipment cut his material, time and labor costs in half.

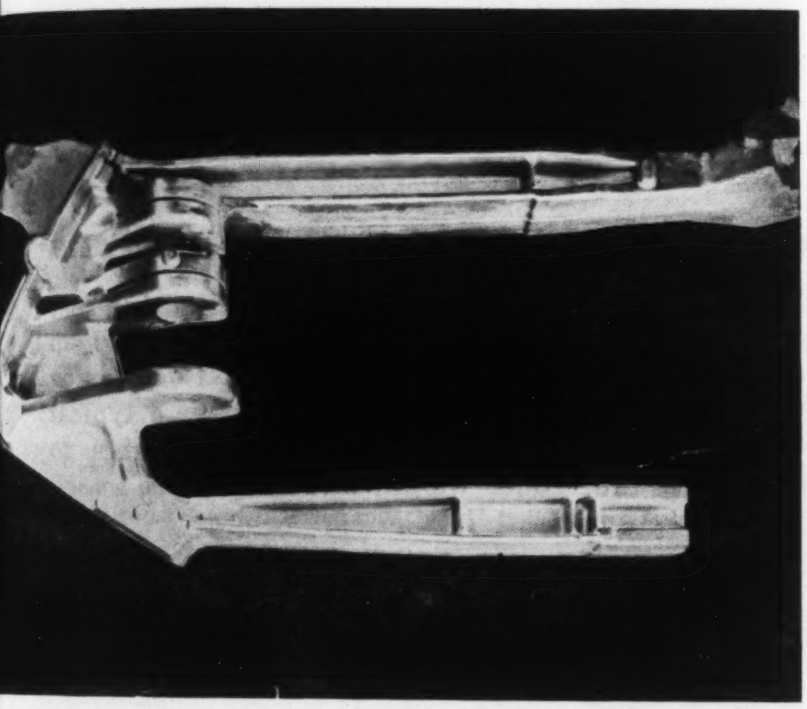
The screw, cast of ACI Type CF 8 stainless steel (nominal composition: 19 chromium, 9 nickel and 0.08% carbon), is 60 in. long with 6-in. dia flights. The shaft tapers from 3 in. to 3⅛ in. over the full length (see photo).

Previously, screws were fabricated from straight carbon steel bar stock. Even with a less complicated design, the machining required to finish the screws was expensive and time consuming; it cost the company approximately $1500 in material and at least 100 man hours in labor. With the cast screws, the company now turns, finishes and polishes the screw in about 42 hr, and over-all costs have been cut to approximately $570.

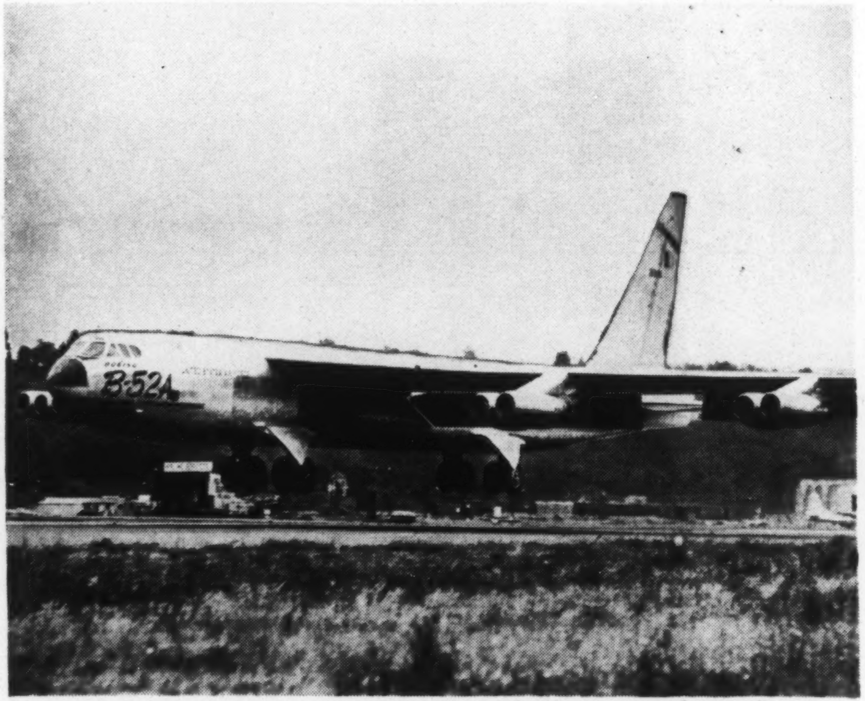
From hand forging . . .



. . . to blocker-type die forging . . .



. . . to precision forging . . .



Aluminum Co. of America

. . . to material, time and money saved *on Stratofortress landing gear bulkhead components.*

Precision forged aluminum saves money, material

The switch from hand forging and machining to precision forging of the aluminum landing gear bulkhead components used on Boeing's B-52 Stratofortresses is an effective demonstration of the benefits that can be derived from careful selection of the forms in which materials are used.

The original part was produced by machining 1300 lb of aluminum from a 1625-lb contoured hand forging. The hand forging was made by pressing and shaping an aluminum blank between flat dies until it had a rough outline of the finished part (see photo above left).

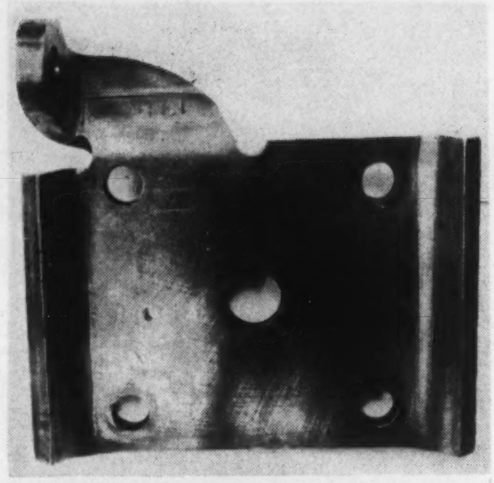
The next improvement was to use a blocker-type die forging made by squeezing a blank between a single set of impression dies to obtain the finished product's general shape (see photo above right). This method reduced 750 lb from machining requirements. However, 645 lb of aluminum were still being chipped away.

Final step in the program was to forge the part to precision tolerances on a recently developed 50,000-ton press. The part now leaves the press weighing only 289 lb—67% less than the blocker-type die forging—and very little machining is required (see photo at bottom left). Man-hour requirements per part have been cut by 62%, savings of thousands of dollars in machine tool costs have been realized, and the amount of aluminum originally needed for one set of bulkheads now produces eight sets.

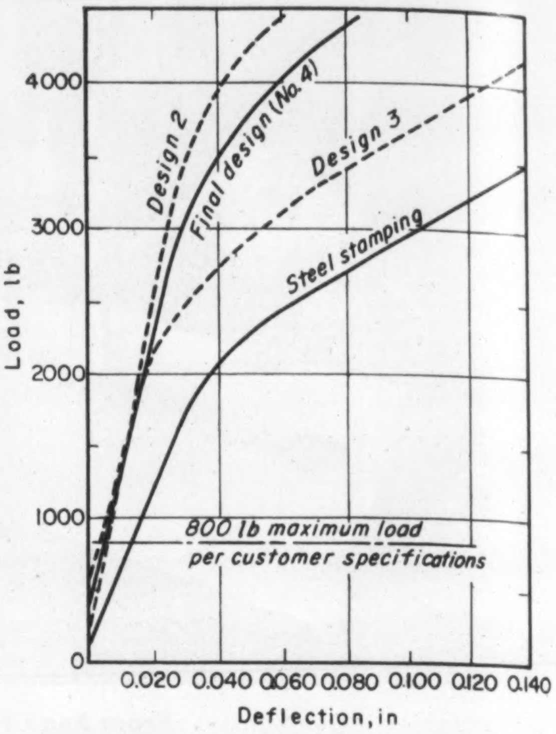
MATERIALS AT WORK

Bracket redesign: a step-by-step analysis

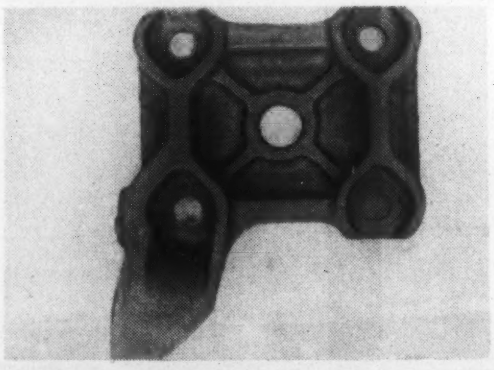
The spring bracket described here is of limited interest in itself except to the automobile manufacturer for whom the Central Foundry Div. of General Motors Corp. made this study. However, the bracket is significant as a typical example of what can be done through careful design to increase strength and reduce weight and costs. (This article is based on an entry in last year's "Best Use of Materials" Awards Competition.)



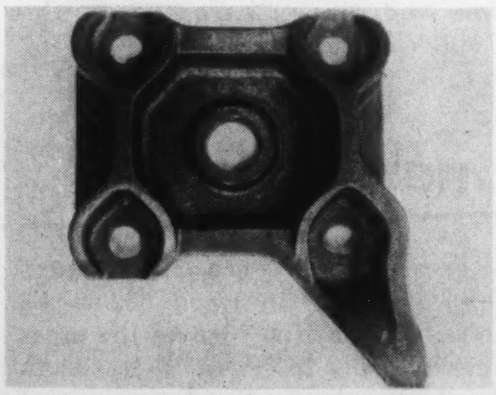
1. Original stamping made from 0.48-in. thick SAE 1015 steel. The part weighs 4.2 lb. Problem: to produce a casting of this same part which will withstand 800-lb maximum push or pull load on a shock absorber ear and 75 ft-lb torque on each unlubricated U-bolt at each locknut.



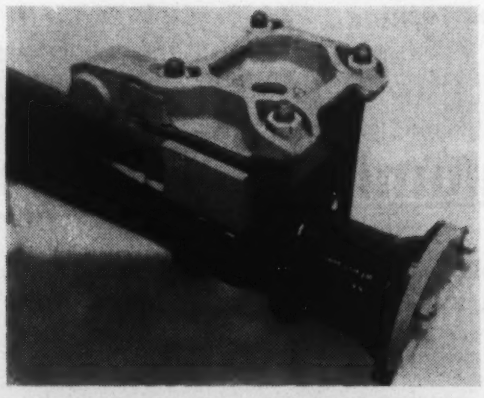
Improved strength and rigidity *of casting over stamping is illustrated in load-deflection graph based on stress analysis.*



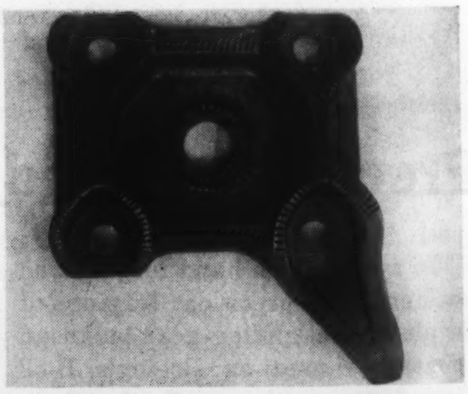
2. Casting design No. 1. Although this casting made of pearlitic malleable iron is lighter than the original stamping (4 lb), it was found to be over-designed. Preliminary tests indicated that ribs can be eliminated and the shock absorber ear can be tapered.



3. Casting design No. 2. Using the same material, but eliminating ribs and tapering ear resulted in further weight reduction to 3.25 lb. Next step was to submit part to stress analysis to see whether weight could be further reduced.



4. Method of test. Casting is fastened on production axle using rubber pads and steel block to duplicate spring thickness. Production U-bolts and locknuts are also used to duplicate actual loading conditions and torque characteristics. Strain gages are fastened to U-bolts; readings are taken at required torque.



5. Stress pattern. Using brittle lacquer, stress pattern on casting is established. The areas of highest stress concentration are determined so that casting weight can be further reduced without reducing the strength of the part. *(continued on p 224)*

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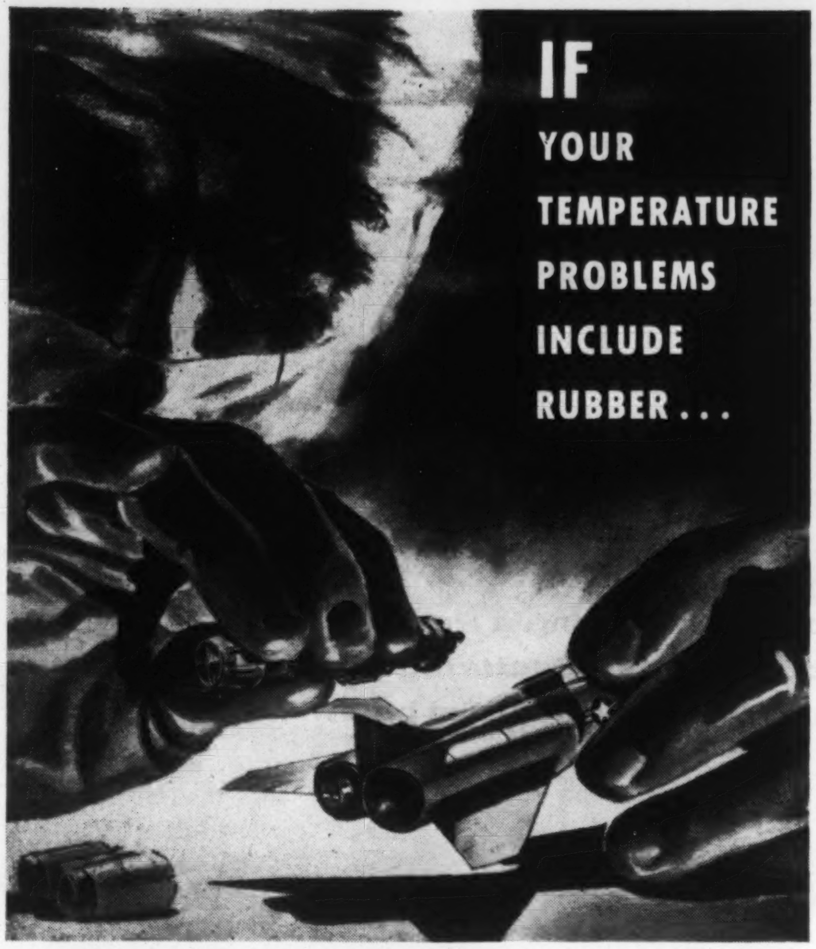

CALL A Silicone SPECIALIST FROM STALWART

The magic of Silicone rubber is no longer new. It is generally understood that these materials will withstand extremely high and low temperatures. However, specialists are required to compound these new Silicones to provide additional features. In most applications, parts must withstand a variety of influences . . . such as hot lubricating oils, abrasion, ozone, compression.

Temperature resistance is important . . . but not enough. That's why we recommend that you call a SILICONE SPECIALIST from STALWART when you have a problem that involves temperature.

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RUBBER COMPANY

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Letters to the Editor

Silicone rubber

To the Editor:

I have just finished reading your August issue and, as usual, the time was well spent. The article by Mr. Woerner on elastomeric linings, p 94, is a worthy addition to our data center, but one point bothered me. On p 98 it is stated that below –70 F the properties of silicone rubber become questionable. This is valid for general-purpose silicone rubber, but extreme low temperature silicone rubber is useful at least as low as –150 F.

D. P. SPALDING
Rubber Market Development
General Electric Co.
Waterford, N. Y.

Gun bluing

To the Editor:

The manual entitled "Conversion Coatings for Metals," Aug '57, was very interesting and informative. What method is used by our leading gun manufacturers for bluing rifles and shotguns? Where can I get details on procedures, equipment and supplies for this type of coating?

E. H. HILDEBRAND
Baytown, Tex.

Many of these finishes are actually black. One method is to place parts in a retort with charred bone, heat to 800 F, then add bone or carbonia oil and heat for several hours. The final finish is secured by dipping the parts in sperm oil or tumbling them in oily cork. This, and other finishes, are described in the ASM Metals Handbook.

Metal-ceramic bonding

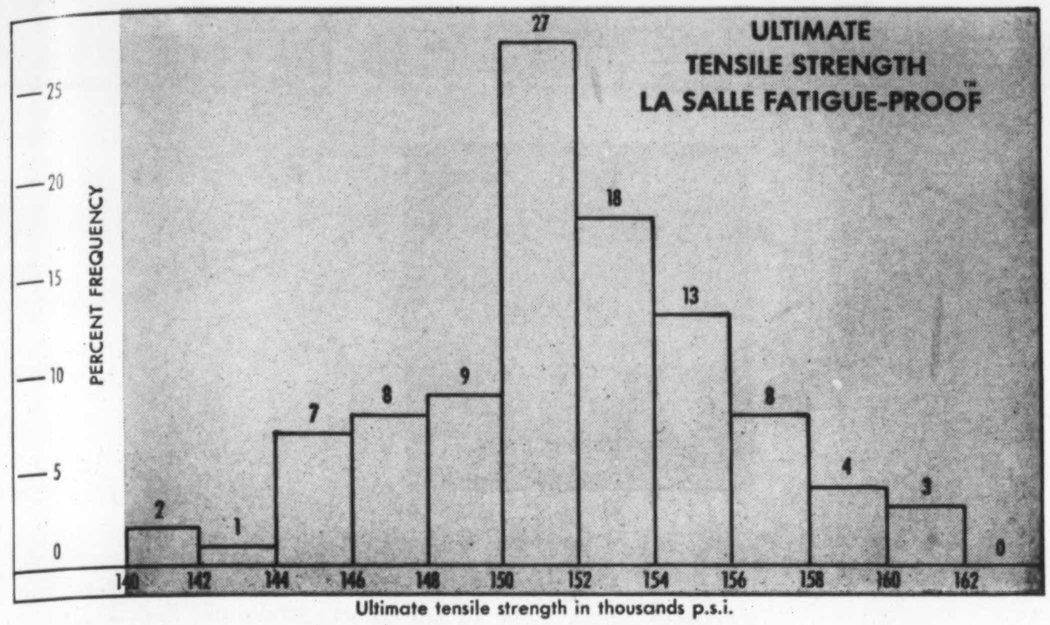
To the Editor:

I am attempting to find general information about soldering, brazing and bonding materials. I also have a particular problem concerned with attaching electrical leads so as to make positive contact with a metal permanently bonded to a ceramic. The joint must withstand 800 F, but must not be formed at higher than 1000-1050 F.

I would also like to learn what is known about metal-to-metal and metal-to-ceramic bonds in general, the types of bond (chemical or mechanical), what materials add or detract from bond strength, etc.

DOUGLAS G. RITCHIE
Consolidated Electrodynamics Corp.
Pasadena, Calif.

A copy of our manual, "Selecting Brazing and Soldering Materials" (Mar '52), should help. Among many possible information sources are: Materials Technology for Electron Tubes, *Reinhold Publishing*



The above chart shows the range of ultimate tensile strength over a period of one year's production. Average value obtained is approximately 150,000 p.s.i.

"e.t.d."™ Process Applied to FATIGUE-PROOF™ Steel Bars Gives Added Strength, Greater Uniformity, Better Machinability

Guaranteed 140,000 p.s.i. minimum tensile...no heat treating necessary

Six important physical and mechanical properties, (1) a high strength level, (2) exceptional uniformity, (3) improved machinability, (4) wear resistance, (5) resistance to fatigue, and (6) dimensional stability, are desirable features of La Salle "FATIGUE-PROOF" steel bars, produced by the new "e.t.d." (Elevated Temperature Drawing) process.

Strength . . . "FATIGUE-PROOF" is a carbon steel bar which replaces both hot-rolled or cold-finished carbon and alloy heat-treatable steel bars. Production figures show hardnesses between Rc 30 and Rc 36 (with a minimum hardness guarantee of Rc 30). The guaranteed minimum tensile strength is 140,000 p.s.i. with a 150,000 p.s.i. average.

"FATIGUE-PROOF" is better than a heat treated bar because it is not quenched and tempered and so the problems frequently associated with quenching and tempering such as (1) quench cracks, (2) non-uniformity of section, (3) soft centers, and (4) heat treat distortion are eliminated. Costly secondary operations such as grinding, cleaning, and straightening are not necessary. Rejects are minimized.

Exceptional uniformity... "FATIGUE-PROOF" is remarkably uniform from bar to bar, end to end, size to size, and lot to lot. Design and production engineers can depend upon it being the same from day to day and job to job.

Individual processing of each bar plus the inherent good qualities and characteristics of the "e.t.d." process account for the excellent uniformity. Microstructures are uniformly pearlitic.

Improved machinability... "FATIGUE-PROOF", made by "e.t.d.", machines 50% to 100% faster than heat treated alloys, and 25% faster than annealed alloy steels. It machines with a very fine finish, and gives excellent tool life. These characteristics make it an ideal steel for production parts.

Wearability . . . Field applications such as gears, pinions, pins, and screws prove that "FATIGUE-PROOF" has good wear resistance. It resists galling and seizure, partly due to its hardness . . . and probably due to the anti-weld characteristics of its chemistry. Further, "FATIGUE-PROOF's" pearlitic structure appears to resist sliding wear better than a quenched and tempered structure of equal hardness.

Resistance to fatigue . . . The chief reason for the failure of highly stressed parts is fatigue. While part shape, unfavorable residual stresses, tool marks, gouges in highly stressed areas, and many other factors contribute to fatigue failure, most materials have also an inherent quality . . . endurance limit that is an indication of ability to resist fatigue.

"FATIGUE-PROOF" has this inherent quality to resist fatigue. Laboratory tests prove that fatigue properties are at least comparable to those of expensive heat treated steels of the same strength level. Numerous field tests, under severe operating conditions, have proved this to the satisfaction of many manufacturers.

Dimensional stability... "FATIGUE-PROOF" maintains a high degree of dimensional stability in machining because of its low order of residual stresses.

Details of the e.t.d." process . . . Elevated Temperature Drawing involves (1) the selection of bar chemistry, (2) the amount of reduction in cross-sectional area of the bar as it is drawn through a special die, and (3) a preselected elevated drawing temperature which will result in the desired final properties.

Although the "e.t.d." process was first announced early in 1957, it has been used in the production of "FATIGUE-PROOF" steel bars since September 1955. Four U.S. Patents (Nos. 2,767,835, -6, -7, and -8) were granted October 23, 1956, covering the "e.t.d." process — an exclusive development of La Salle Steel Company.

How manufacturers can obtain sample Fatigue-Proof steel bars for testing

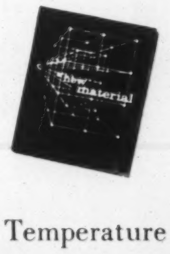
LaSalle Steel Company has announced that samples of "FATIGUE-PROOF" steel bars, made by the "e.t.d." (Elevated Temperature Drawing) process, are available for test purposes on a no charge basis to manufacturers where it appears that "FATIGUE-PROOF" can help improve products and reduce production costs.

Applications for a sample bar are invited from manufacturers making parts from either hot-rolled or cold-finished carbon or alloy steel bars which require high tensile strength.

Interested manufacturers may write for a test sample by sending a blueprint or application details direct to LaSalle Steel Company, Advertising Department, P. O. Box 6800-A, Chicago 80, Ill.

"FATIGUE-PROOF" is also available from your steel distributor . . . write for his name.

Brochure tells story of Fatigue-Proof steel bars



"A New Material" is the title of a 24-page booklet which gives detailed information covering La Salle "FATIGUE-PROOF" steel bars made by the Elevated Temperature Drawing process.

The booklet presents the results of more than one year's tests of production samples and reports on eight application case studies. Copies available on request.

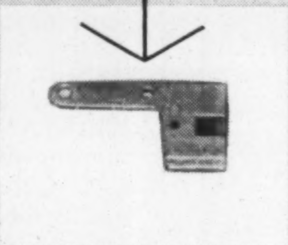
TM—Trademarks of La Salle Steel Company

La Salle STEEL CO.

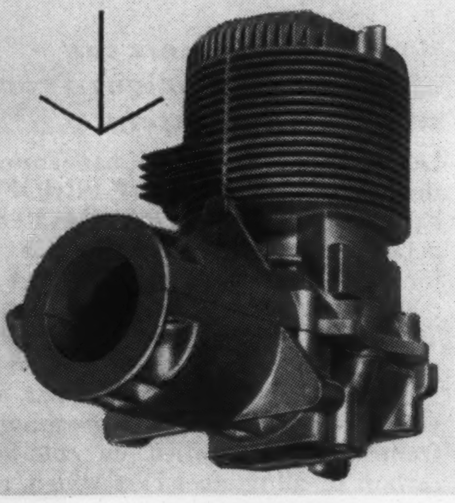
1418 150th STREET
HAMMOND, INDIANA

For more information, turn to Reader Service card, circle No. 363

FROM
camera parts



TO
engine cylinders



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Letters to the editor

Corp., N. Y.; "Review of High Temperature Metal Ceramic Seals," Jnl. of the Electrochemical Soc. *Vol. 102, No. 7; "Applications of Fundamental Concepts of Bonding Metals and Ceramics," WADC Technical Report 53-356, Office of Technical Services, Dept. of Commerce, Washington, D. C.*

Synthetic rubber

To the Editor:

We have noted with interest Manual No. 141 in the September issue of MATERIALS IN DESIGN ENGINEERING. We are interested in keeping abreast of the different available types of synthetic rubber in all its classifications, particularly as applied to automotive uses. It is requested that you forward any additional engineering data on synthetic rubber which is available as of this date.

D. E. MURRAY
Asst. Purchasing Consultant
International Harvester Co.
Fort Wayne, Ind.

There is a great deal of engineering data available on synthetic rubbers. A list of producers has been sent to Mr. Murray.

Conductive rubber

To the Editor:

I believe I read an item in your magazine which mentioned a rubber or alkyd material matting which becomes conductive under pressure. A local supermarket uses some such material in the door actuator but does not know the manufacturer. Certain designs upon which I am working at the moment might be improved if I could get immediate information on this.

WILLIAM EDLICH
Dover, N. J.

We do not know of a conductive alkyd material. Several types of conductive rubber are available and names of suppliers have been sent to Mr. Edlich.

Cutting plastics sheet

To the Editor:

Kindly recommend a source of dimensionally stable plastics sheet material which can be worked with conventional woodworking machinery and cutters. Thickness would vary from ⅛ to 1 in.

S. W. GEIPEL
Metallo Gasket Co.
New Brunswick, N. J.

We suggest contacting one of the high pressure reinforced plastics laminates producers. The majority of these laminates can be worked with conventional woodworking equipment, although the paper-base grades will probably prove most satisfactory.

ONE POINT OF VIEW

Want help with your job? Use the Materials Selector issue

How do you go about selecting the materials out of which your parts and products are to be made? This and similar questions were asked of many engineers and designers when we started planning our special reference issue nearly two years ago. Our goal was to design an issue that would provide you with the basic data and information needed for a rational approach to materials selection.

Now you have it

At that time the issue was no more than a faint gleam in our eyes. Now the faint gleam has become a reality. Within the last few weeks you have received your copy of the *Materials Selector* Reference Issue. We believe it comes close to achieving our original aims, and we hope you will agree.

A quick examination of the issue will show you why we called it the *Materials Selector*. It is a reference manual that embodies the basic data and steps for a systematic approach to materials selection. There are two major sections: a Data Section and a Directory Section. The Data Section contains extensive data on virtually all important engineering materials (including finishes and coatings) and the forms in which they are available. The Directory Section lists the sources of supply of these materials, forms and finishes.

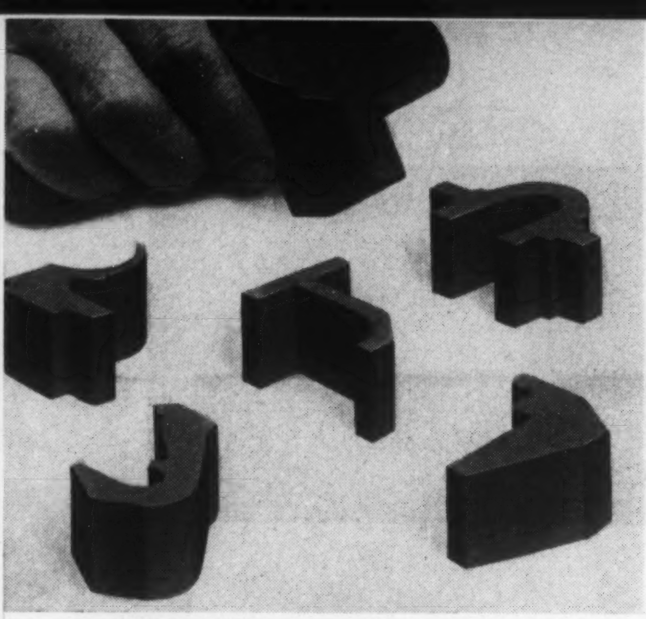
The most distinctive feature about the Selector is its organization. All of the data and information are organized in such a way that you can proceed systematically to narrow your choice of the materials that will meet the specific service requirements of your part or product.

How it works

For example, there are data sheets that compare various materials with respect to a given property. From them you can select the materials that will meet your most critical requirements. These materials then can be further investigated by turning to the data sheets listing the typical properties of specific materials. Proceeding still another step, information on the characteristics, advantages and limitations of the various forms of the materials can be obtained in the section devoted to this subject. And finally, the Directory provides the names and addresses of suppliers who can provide the other data or help you may need on properties, availability and cost.

A systematic approach

Materials selection probably will never be reduced to the mathematical precision possible in many phases of engineering and design. But this does not preclude the use of systematic approaches to this complex problem. The *Materials Selector* Reference Issue is one such approach. We hope you find it useful. We also hope you will send us your comments and suggestions so that we can make it even more useful to you next year.



***Complex shapes** are made by the hot extrusion process.*

Hot Extruded Steel Shapes

can save you money...

by R. L. Hugo,
Jones & Laughlin Steel Corp.

■ Production of complex shapes by hot extrusion, practiced for many years in nonferrous metals, was extended to steels by introduction of the Ugine-Sejournet process (MATERIALS & METHODS, Mar '50, p 56). By following hot extrusion with cold drawing, it is possible to produce steel sections of complicated design with the close tolerances that are characteristic of cold drawing. Hot extruded, cold drawn sections are now being produced for many applications (see photos), including such diverse items as revolver parts and helicopter rotor blade sections.

Advantages

Production of shapes by hot extrusion has a number of advantages:

1. Since extrusion is completed in a few seconds, the temperature remains practically constant. As a result mechanical properties are uniform throughout the bar and there is less directionality than occurs in rolled sections; transverse properties are virtually equal to longitudinal properties. In addition, there is practically no decarburization.

2. Complex sections that cannot be produced by rolling, can be produced economically by hot extrusion.

3. Since the dies cost much less than rolls, hot extrusion is economical for small quantity production.

4. Scrap loss is small, a factor of considerable importance in producing parts from high cost metals.

5. Because of the short time required to make dies and set up the press, orders can be executed rapidly.

Following hot extrusion with a cold drawing operation gives additional advantages:

1. Tolerances are frequently close enough to reduce machining to a cut-off operation. At present, shapes are produced to a tolerance of 0.003 in.

2. Fillets, fins and deep slots that cannot be produced economically by hot extrusion alone can be introduced into the section during cold drawing.

3. Surface finishes are usually better than those obtained by rolling.

Limitations

Like all other production methods, hot extrusion has certain limitations that must be considered in designing parts. Generally these limitations involve size and shape.

Size—Because of mill capacity, production at Jones & Laughlin is limited to shapes measuring not more than 3 in. between the extremes; a shape that can be inscribed into a 3-in. dia round can be produced, but it might be impossible to produce a part inscribed into a 3-in. square because the diagonal is greater than 3 in in length.

There is also a minimum size For economical operation, it is impractical to extrude sections weighing less than 0.7 lb per ft —roughly the weight per foot of a ½-in. round.

Wall thickness of a section can be no less than 1/8 in. and preferably not less than 3/16 in. An increase in height of the wall requires an increase in thickness

Shape—Shallow radii and irregularities in the surface or periphery of the bar are relatively simple to produce by extrusion. It is these configurations that are sometimes most expensive to produce by machining.

On the other hand, certain shapes are not economically suited for production by hot extrusion Deep slots, undercuts and fine tooth shapes are not practical at present because heat and pressure cause rapid erosion of the die material at the sharper areas of the die. A rule of thumb: a slot should be three times as wide as it is deep and should have generous radii at the two bottom fillets.

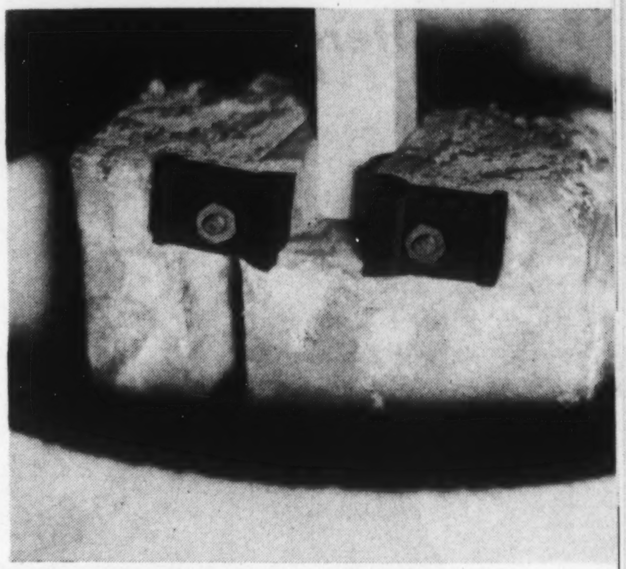
Small acute angles are not desirable for steel extrusion. At fillet points, a minimum radius of 1/32 to 1/16 in. is desirable.

Materials

Extrusions are regularly produced from the commonly used steels, including 1015, 1018, 1020 1045, 1050, 4130, 4340 and 8630 In addition, extrusions can b produced from the 3300 series of nickel-chromium steels, the 4300 series of nickel-chromium-molybdenum steels, the 6100 series of chromium-vanadium steels, and some tool steels.

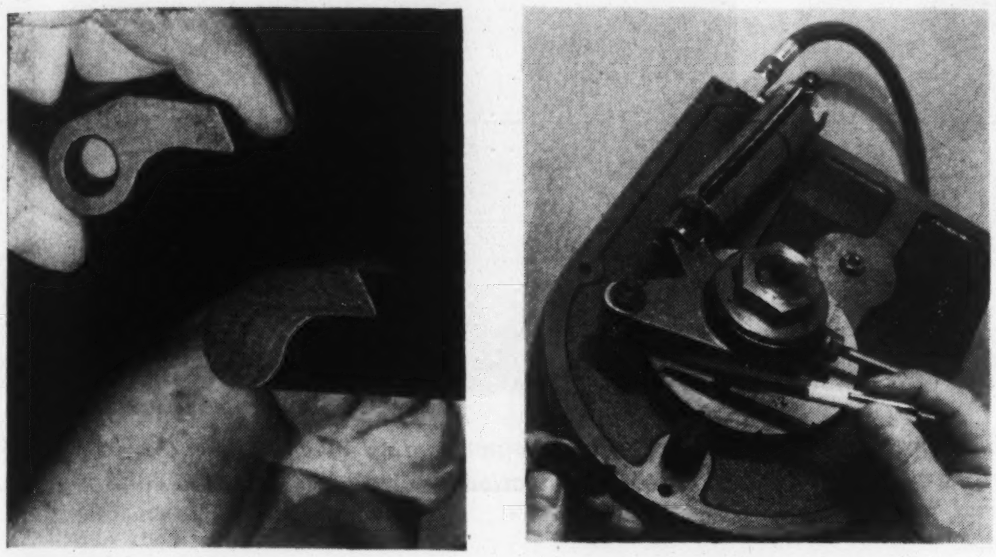
Applications

Hot extruded, cold drawn sections are used in airframe components such as channels, angles and hinges; as the wing leading edges in guided missiles; and to attach the blades to the shaft in helicopters. They are used as various components of business machines, machine and hand tools, textile and woodworking machinery, and mining equipment. A few specific applications are illustrated on this page.

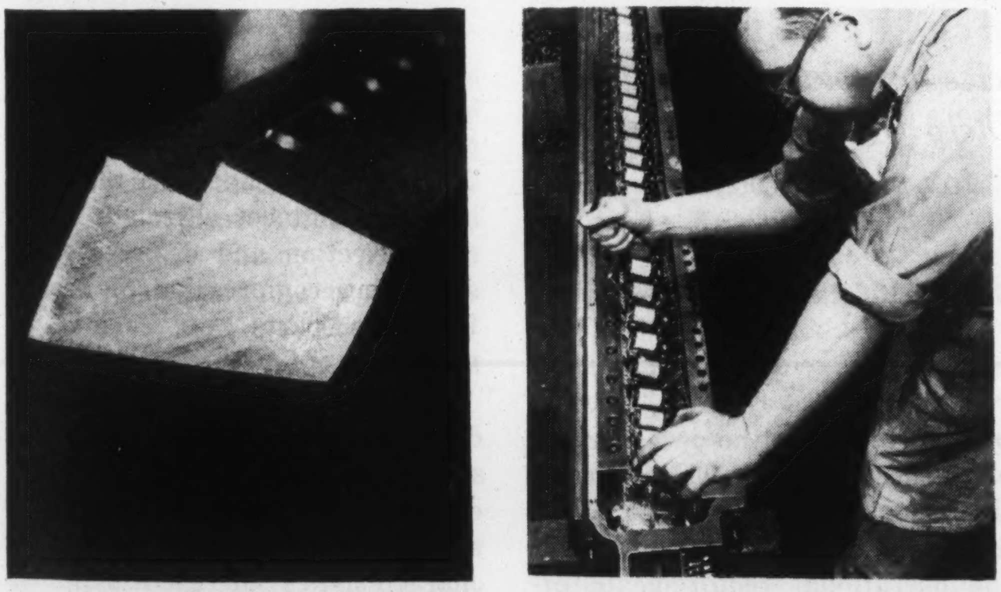


Clamp *Fansteel Metallurgical Corp. uses clamps produced from 1018 steel to hold molybdenum bars during sintering. The clamps were formerly machined from cold drawn flat stock; replacement by a hot extruded, cold drawn shape has resulted in a saving of 76%.*

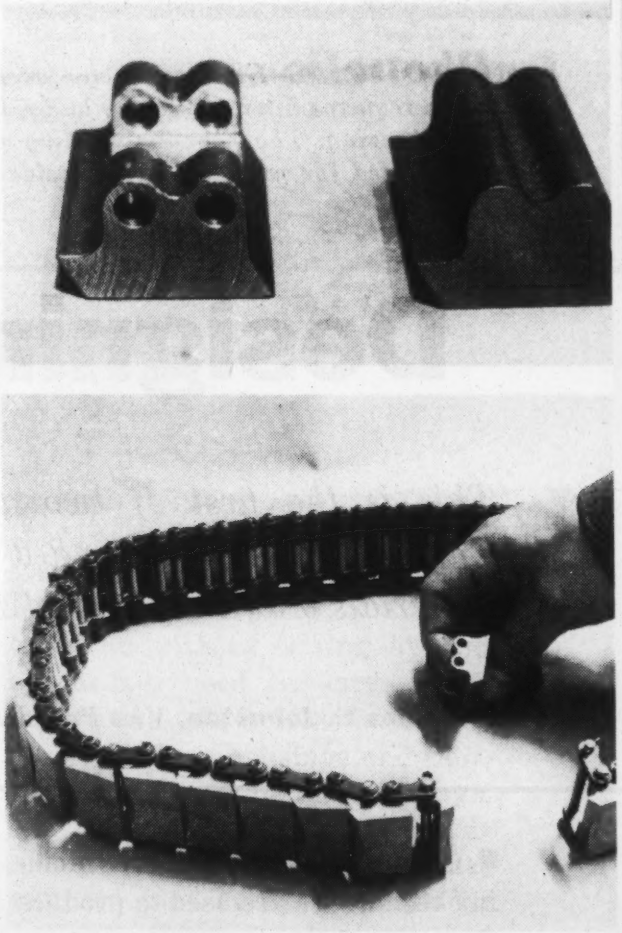
...and here's how



Pawl *Snow Mfg. Co. is using a hot extruded, cold drawn shape as a pawl on a dial indexing fixture for a drilling and tapping machine. Only operations required are cutting from the extruded section and drilling a hole. Previously, the pawl was machined from a hot rolled flat section; changing to the extruded section resulted in a 75% reduction in cost.*

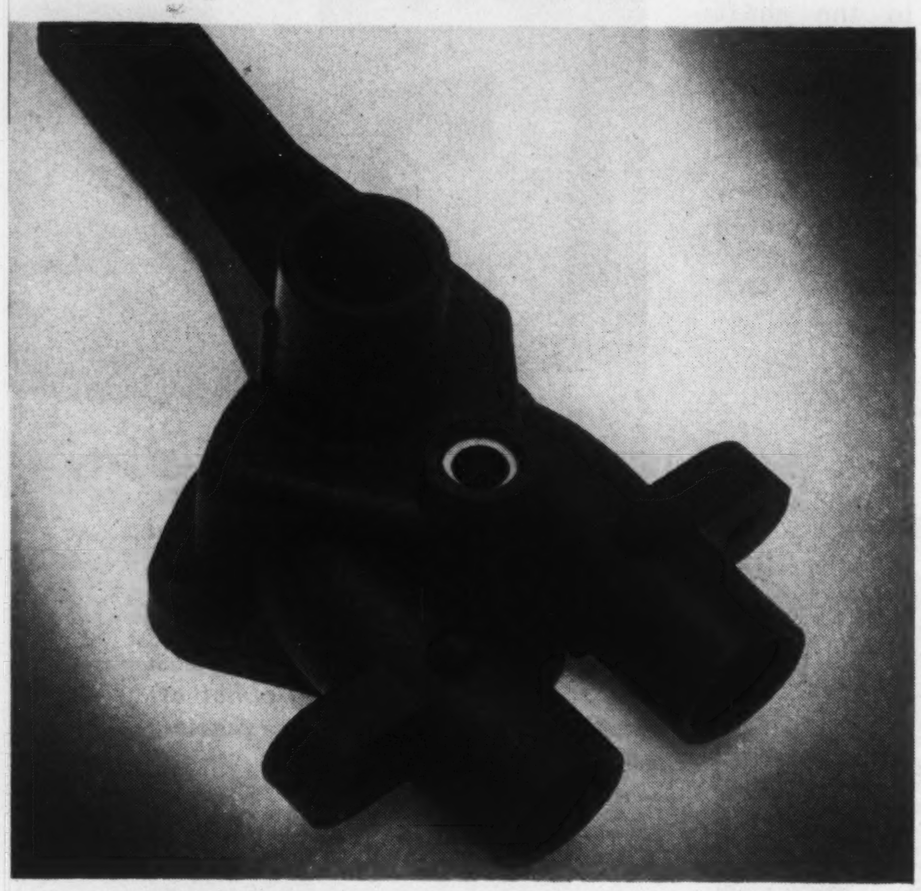


Bar *Goss Printing Press Co. is using a hot extruded, cold drawn shape about 70 in. long as an ink control device for the Headliner printing press. This section is supplied stress-relieved and cut to length, ready for installation in the press. The section is made from AISI 1018 steel and was formerly machined from rectangular hot rolled flats in nine operations. The extruded bar requires only drilling of holes before installation; the change has resulted in a saving of 50%.*

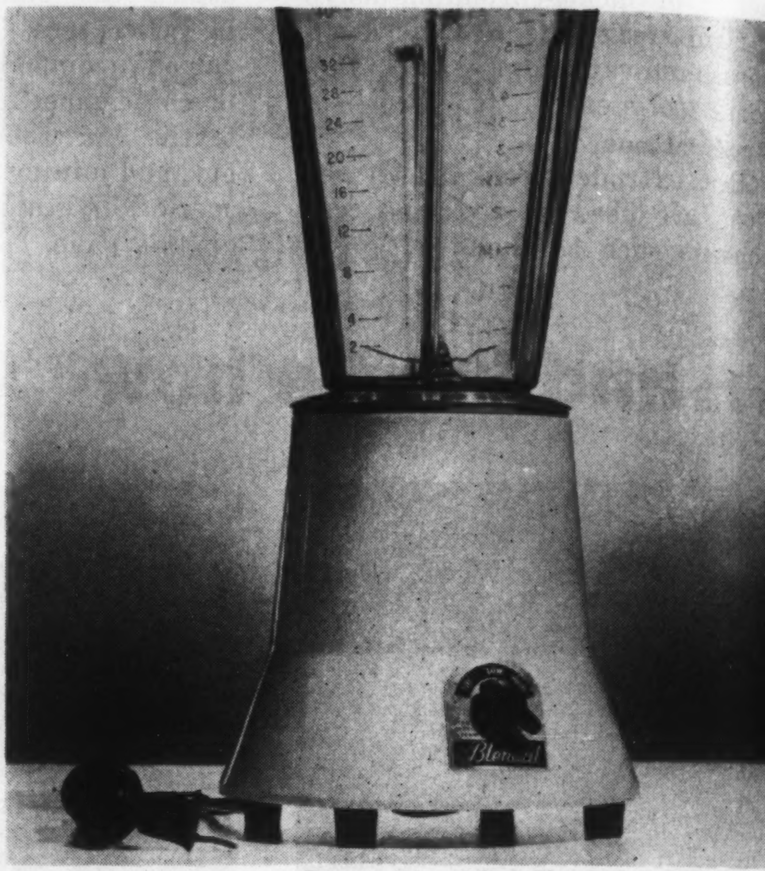


Chain link *Hopkins Machine Co. produces a machine for coating paint can ears with solder, one component being a chain that carries the ears into the solder pot. This part, formerly made of forged AISI 1041, is now produced from an extruded shape at a saving of 20% in the overall cost of the chain.*

Here are typical compression and transfer moldings made of



Phenolic *Diverter valve for Norge washing machine requires intricate coring and a brass insert to serve as a bearing. The phenolic molding material is specially formulated for wet-inside-dry-outside service.*



Barrett Div., Allied Chemical & Dye Corp.

Urea *Base for a blending machine is molded of urea, permitting production in virtually unlimited colors.*

Designing for Compression

This is the first of two articles on plastics moldings. These articles are intended to help you select the proper materials and design effectively for plastics parts.

by **James E. Johnston,** *Vice President, Chicago Molded Products Corp.*

■ Compression and transfer molding techniques are used to produce thermosetting plastics parts economically and with consistent quality. The molding methods are capable of relatively high production rates, and can be adapted to produce a wide variety of shapes and sizes at reasonable cost.

In designing a plastics molding, materials selection cannot usually be divorced from the development of the design shape. The two considerations are interrelated. The materials must be selected to meet the operational requirements of the part. The shape of the part must then conform to the requirements of the most economical molding method for shaping that material.

The purpose of this article is to summarize the types and characteristics of materials that ca be specified as compression o transfer moldings, and to mak design recommendations that wil help the engineer correlate materials selection and design befor specifying compression or trans fer molded parts.

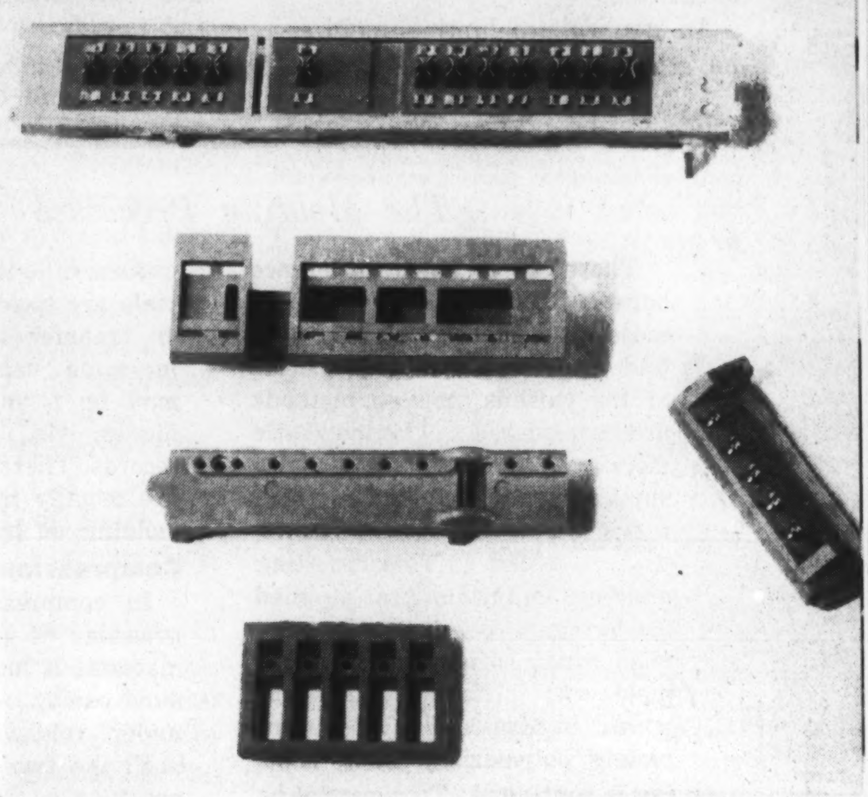
Materials

Practically all plastics used fo compression and transfer moldin are thermosetting. The followin discussion is intended only t summarize the most importan characteristics of each type o molding material.

Phenolic — Perhaps the mos widely used compression an transfer molding materials ar phenolics. The molding powder are relatively low in cost (approxi mately 20 to 24¢ per lb). Th

the four most common materials

Melamine *Beer tap of melamine has compound curvatures making application of the integrally molded decorative overlay extremely difficult.*



Barrett Div., Allied Chemical & Dye Corp.

Alkyd *TV tuner segments require the good dielectric qualities of a mineral-filled alkyd, and must be compression molded at relatively high speeds.*

and Transfer Moldings

moldings have good heat resistance, good electrical insulating properties, good rigidity and strength, low moisture absorption, good dimensional stability, and a hard lustrous surface. Phenolic compression moldings as large as 60 lb have been produced using large presses and high frequency induction heating.

The principal limitation of phenolics is their colorability; color is generally confined to blacks, browns and other dark shades since pastel shades and light colors have a tendency to fade in phenolics.

Phenolic molding compounds are available with a variety of fillers intended to enhance various physical or electrical properties. The more common types are: 1) wood-flour, which provides good molding characteristics and an excellent surface finish, in addition to good mechanical and electrical properties, 2) cotton flock, which provides high tensile and impact strengths, 3) chopped cloth, which provides high impact strength, 4) mica, which provides outstanding electrical properties, and 5) glass fibers, which provide maximum strength and resistance to high and low temperatures.

Urea—Urea molding compounds, usually more expensive than phenolics (approximately 35¢ per lb), are used primarily for their colorability. Colors available range from pure white through pastels to brilliant hues.

Urea compounds are usually filled with alpha cellulose and are available with a variety of flow characteristics. The softest flow formulations are capable of flowing for a longer period of time in the mold without setting up and are usually used for large moldings—particularly those with deep draws, such as housings and cabinets—or for transfer moldings. The stiffer flow compounds generally require shorter cure times and are best suited for molding buttons, closures, electrical and stove hardware, and other smaller parts.

Melamine — Melamine molding compounds, higher in cost than ureas (about 40 to 45¢ per lb), provide physical, mechanical and electrical properties generally superior to those of ureas. Melamine moldings maintain their properties over a substantially wider temperature range than the ureas, and also have appreciably more resistance to moisture and chemicals.

In general, melamine moldings have high surface hardness, excellent resistance to boiling water and strong solvents, color stability, good dielectric properties and resistance to tracking. They are also self-extinguishing, odorless and tasteless.

Melamines flow for a relatively long period of time in the mold and thus are well suited to transfer as well as compression molding. Even high impact strength grades usually can be transfer molded with proper mold design.

Alkyd — Moldings made from

The Molding Processes

There is a basic difference between thermoplastics and thermosetting resins which should be understood before the intricacies of the various molding methods are considered. Thermoplastic molding materials are usually supplied as polymers which soften when heated and harden when cooled. Thermosetting molding materials are supplied as partially polymerized materials which soften sufficiently to mold on initial heating, but which harden and cure (completely polymerize) when heating is continued. They cannot be softened by subsequent heating.

As a rule, thermosetting materials are molded by compression or transfer techniques, though in some cases thermoplastics may be formed by these techniques, viz., vinyl phonograph records. Thermoplastic materials are usually molded by injection molding or by extrusion.

Compression molding

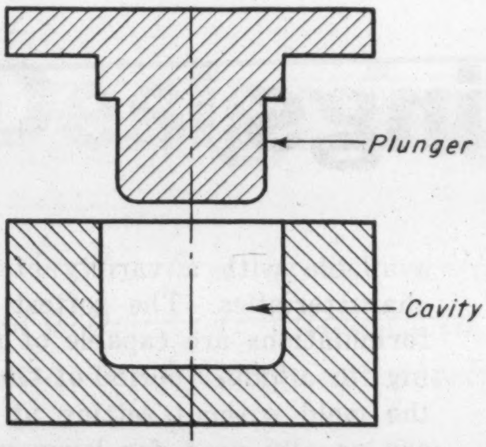
In compression molding, the granular or preformed molding material is loaded into a heated mold cavity. The mold is closed under relatively low pressure until the two mold halves exert pressure on the material. This application of heat and pressure softens the material and as higher pressure is applied, the material is forced into all parts of the mold. The mold remains closed and under pressure until the part is set or cured, after which the part is removed.

Four basic types of molds are used in compression molding. Though usually the selection of the type of mold should be left up to the molder, a general understanding of the types may be helpful to the designer or engineer.

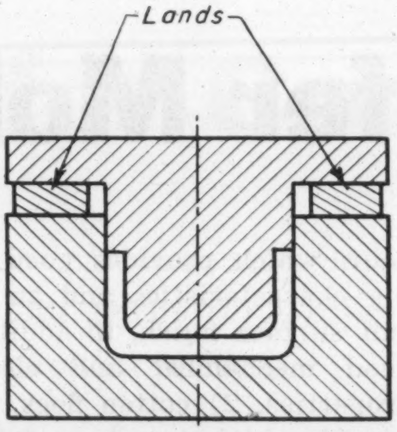
1. *Fully positive* molds are used where maximum density and superior electrical and physical properties are required. The full molding pressure is exerted directly on the material throughout the entire molding cycle. The mold plunger telescopes into the cavity, preventing escape of excess material. The mold is stopped by the compressed plastics material, determining the height of the piece and the thickness of the bottom. This technique is generally not recommended for multi-cavity molds.

2. *Landed positive* molds are so constructed that the travel of the plunger is stopped at a predetermined point by metal lands. They are sometimes used to control the height and thickness of parts, as well as to compensate for variations in weight of charge. This is considered poor practice when maximum density is desired in the molded part.

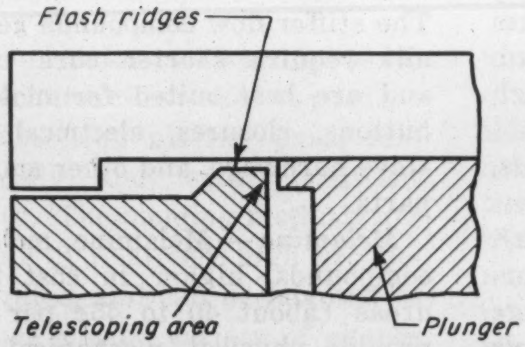
3. *Semipositive* molds contain such features as flash ridges, telescoping parts and external lands. As the mold closes, excess plastics material escapes between the flash ridges, equalizing differences in weight of charges. The subsequent telescoping action traps and compresses the material with direct pressure, helping to assure proper density



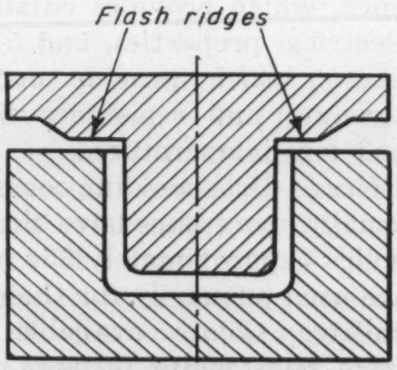
Fully positive mold (open)



Landed positive mold (closed)



Semipositive mold (closed)



Flash mold (closed)

alkyd or polyester resins have exceptional dielectric characteristics, arc resistance and dimensional stability which are retained after exposure to high humidity conditions. Substantial properties are retained after exposure to temperatures of about 400 F. Alkyd compounds reinforced with glass fibers produce parts with exceptional strength and toughness as well as good dielectric properties and dimensional stability.

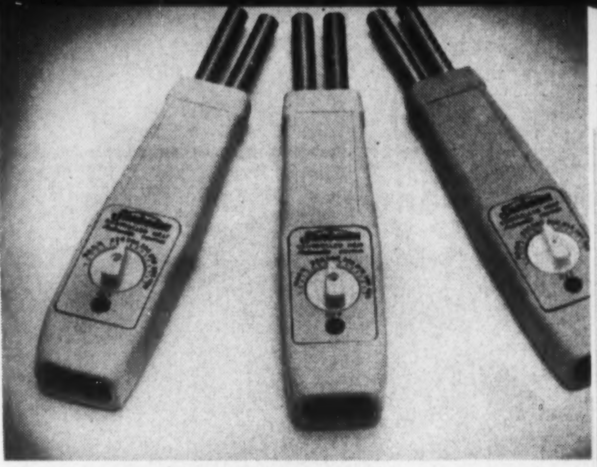
Alkyd materials are fast curing and are available in several forms to meet various design needs (see MATERIALS IN DESIGN ENGINEERING, Oct '57, p 134). Molding compounds may contain mineral fillers or be reinforced with fibrous glass. The mineral-filled compounds are available in both putty and granular forms. Putty is especially useful in encapsulating small electrical resistors and capacitors; the granular type is adaptable to automatic molding of parts for small electrical and electronic components.

Polyester premix materials can be defined as "do-it-yourself" alkyd molding materials. Instead of the molder purchasing a molding compound, he purchases the polyester resin, reinforcement, catalyst and pigment, and compounds them himself. The premix is then usually extruded in rope form, cut to convenient preform lengths and compression molded. Premix molding is one of the fastest growing segments of the polyester or alkyd field.

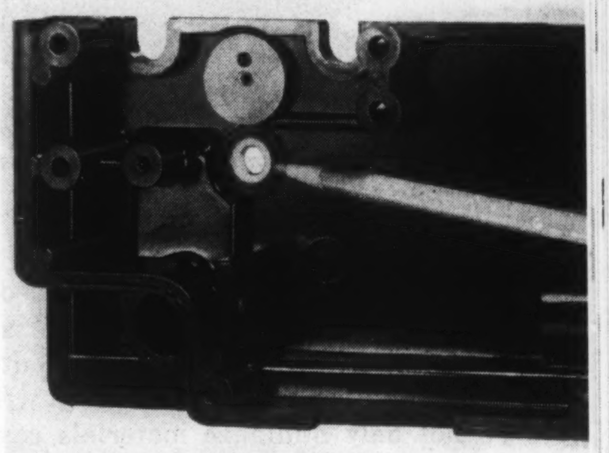
Thermoplastics—Basically, thermosetting materials are compression or transfer molded and thermoplastics are injection molded. It is possible to compression mold thermoplastics, but this is done only in uncommon cases when the design of the part in some way makes injection molding impractical.

Design considerations

The designer or engineer must be somewhat familiar with compression and transfer molding techniques in order to design parts to be produced most effectively by these methods (see accompanying box). With present-day molding techniques, it is possible to mold almost any shape. However, the more complicated the shape, the more expensive will be the part. The design factors discussed here are generally valid. Exceptions to most all of them can be made at appropriate costs.



Polyester *molding material is used to mold heat resistant frying pan handles in a variety of pastel colors.*



Nylon insert *is molded into this phenolic part for a Servel ice maker. Special techniques must be developed since nylon is a thermoplastic material of relatively low melting point, whereas phenolic is thermosetting and must be molded at relatively high temperatures.*

Draft — Usually a minimum draft of ½ to 1 deg should be allowed for easy removal of the part from the mold.

Draws—Draws should not be specified any deeper than are necessary.

Fillets, radii—Curves and radiused corners are far simpler and less expensive to mold than right angles and sharp edges. Sharp corners reduce the life of molds, and can cause poor flow of the molding compound. Liberal use of fillets at inside corners adds strength to the part and also helps to minimize distortion due to warpage.

Beads—Beads, steps, or other discontinuities also may help to prevent warpage in large flat surfaces and can improve the appearance of the molded part. However, always aim for simplicity and smooth flowing lines in the molded part.

of the part. When the mold is fully closed, some of the molding pressure is borne by the lands.

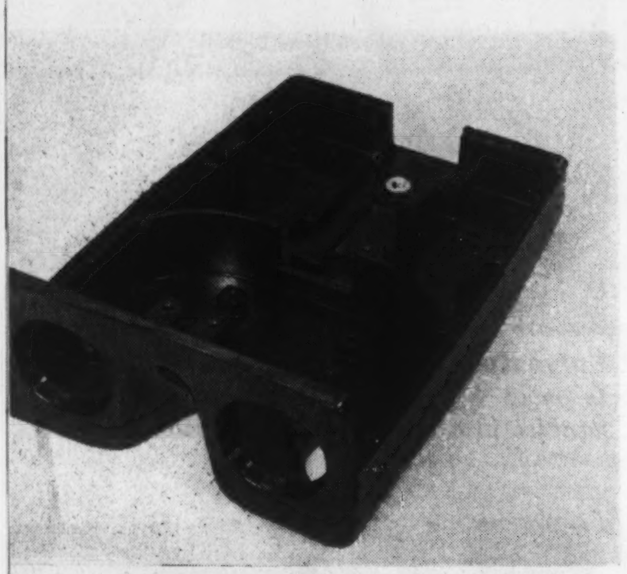
4. *Flash or overflow* molds, less expensive than the other types, are used for molding flat or shallow parts, especially in multiple cavities. They are designed so that the mold halves register exactly. The plunger travel is regulated by areas of reduced size called flash ridges or cut-offs.

Developments in recent years have been toward more completely automating the compression molding cycle, and thus increasing production rates. Improvements have been brought about in mold design, in handling operations and in auxiliary press equipment, especially dielectric preheating units. Tooling for compression molding is less expensive than that for transfer molding and is suitable for production of large parts.

Transfer molding

In transfer molding, the granular or preformed material is loaded into a heated chamber connected to the mold cavity or cavities by sprues and runners. The heat and pressure applied to the outer chamber force the material through the sprue and runners into the heated, closed mold cavity or cavities. Heat is continued in the closed mold until the material has set or cured, after which the mold is opened and the part or parts removed.

Since the mold is closed initially, the amount of flash which must be removed is less than in compression molding. Also, as a rule more delicate mold pins and inserts, and thinner sections, can be used. Transfer molding also provides materials handling advantages in that only one preform, rather than several, is loaded for each mold cycle.



***Transfer molded** phenolic part for a David White slide viewer is relatively complex and requires a brass insert.*

Section thickness—Sections of the molded part should be kept as thin as strength requirements permit; keeping sections thin will not only minimize materials cost but also reduce cycle time because of faster heat transfer during cure. Section thickness should also be kept as uniform as possible to provide most effective flow of resin during molding. In many cases where large areas occur, section thickness can be reduced by use of ribs to provide additional strength.

Parting line—If possible, design the part so that the mold parting line occurs in one plane (see Fig 1). Irregular parting lines cause additional tool expense and added production problems. Also, locate the mold parting line where it will not be readily noticed and where flash can easily be removed after the molding operation. In specifying the part to the molder be sure to stipulate areas where tolerances will not permit location of parting lines or ejector pin marks.

Undercuts—When possible, avoid undercuts that require a split-cavity mold. Such molds reduce speed of production and increase tooling costs considerably. Intricate details, such as lettering, should be located on surfaces parallel to the mold parting line. In designing such lettering, curves and radiused corners should be specified.

Lugs—Projecting lugs in the molded part should not be located near corners or edges, since this necessitates a comparatively weak section of steel in the mold (see Fig 2).

Holes—Wherever possible holes should be at right angles to the surface of the part (see Fig 3). Oblique holes add considerably to cost. In some cases, they may be more economically drilled after molding. Also, holes should be round where possible, since irregular shaped holes are difficult and costly to reproduce in the tooling.

Long, cored holes, especially at the side of the piece, should be avoided. Where essential, ample support should be provided for the pin which forms the hole (see Fig 4).

PROPERTIES OF COMPRESSION AND TRANSFER

Type and Filler ➡	Phenolics					Ureas—Alpha Cellulose	Melamines		
	General Purpose—Wood Flour	Moderate Impact—Cotton Flock	High Impact—Fabric	Heat Resistant—Mineral	Low Loss—Mica		General Purpose—Alpha Cellulose	Impact—Fabric	Heat Resistant—Mineral
PROPERTIES									
Heat Distortion Point (D648), F	260-340	260-340	250-300	290-350	230-320	270-280	285-335	285-335	295-360
Tensile Strength (D651), psi	6500-8500	6500-8500	3300-9000	4000-9000	5000-7000	6000-13,000	7000-8000	6800-7800	4800-6800
Impact Strength (D256), ft-lb/in. notch	0.24-0.60	0.24-0.60	0.75-8.00	0.27-3.5	0.30-0.38	0.25-0.35	0.24-0.28	0.50-0.90	0.20-0.30
Flexural Strength (D650), psi	9000-11,000	8200-11,000	9000-11,600	7000-9000	8000-12,000	10,000-16,000	14,000-16,000	11,000-15,000	7500-11,000
Dielectric Strength (D149, short time), v/mil	200-245	200-245	200-400	100-350	300-460	300-400	300-400	250-350	350-400
Specific Gravity (D792)	1.32-1.45	1.32-1.45	1.36-1.43	1.52-2.00	1.75-1.92	1.47-1.52	1.47-1.52	1.42-1.50	1.70-2.00
Moisture Absorption (D570), %	0.3-1.0	0.3-1.0	0.04-1.75	0.10-0.50	0.01-0.10	0.4-0.8	0.1-0.6	0.3-0.6	0.08-0.14
Flammability	Slight	Slight	None	None	None	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
RATINGS									
Moldability[a]									
Compression	5	5	4	5	5	5	5	4	5
Transfer	5	5	3	5	5	Special conditions	4	2 (limited)	5
Color Range[a]	3	3	2	3	3	5	5	3	2
Color Fastness[a]	3	3	3	3	3	4	4	3	4
Surface Appearance[a]	5	4	3	4	4	5	5	5	5
Surface Hardness[a]	4	4	4	4		4	5	5	5

[a] Ratings are given as follows: 5—excellent; 4—very good; 3—suitable; 2—below average; 1—undesirable.

[b] New polyester molding material developed by Durez Div., Hooker Electrochemical Co.

Rules regarding ratio of depth to diameter cannot be laid down definitely, since the actual ratio possible on a particular hole depends on the design of the part and the capabilities of the molder. As a general rule, however, when designing through-holes the ratio of length to diameter should be no more than four if the part is to be compression molded; no more than eight if the part is to be transfer molded. When designing blind holes, ratio of length to diameter should be no more than two for compression molding; no more than four for transfer molding.

Tolerances—In specifying dimensional tolerances it is an axiom that the closer the tolerances, the higher the cost of the part. Tolerances should never be specified closer than is absolutely necessary.

In general, commercial tolerances on compression and transfer molded plastics parts average approximately ±0.005 in. per in. Closer tolerances can be held. These are a function of part design, tool design and material selected. In almost all cases tolerances closer than ±0.005 in. per in. will add cost to the part.

MOLDED PLASTICS

Polyester		
Premix—Mineral or Glass Fiber	Polyester—Mineral or Glass Fiber	Alkyd—Mineral or Glass Fiber
375-425	300-350	260-325
4000-10,000	6000-8000	4500-6000
3-24	0.30-0.38	0.45-1.10
8000-10,000	10,000-12,000	7000-8500
390-400	300-400	350-380
1.80-1.85	1.60-1.72	1.5-1.7
0.15-0.25	0.4-0.8	0.08-0.11
Slight to self-extinguishing	Slight to self-extinguishing	Slight to self-extinguishing
4	4	4
1	3	3
5	5	5
5	5	5
4	4	4
4	4	4

Recommended standard commercial tolerances for moldings have been developed by the Society of the Plastics Industry, Inc., and published in the *Plastics Engineering Handbook* (Reinhold Publishing Corp., 1954). Standards published include those for the following thermosetting molding materials:

1. Phenolics: unfilled, and filled with woodflour, cotton flock, cotton rag, cotton tire cord, macerated paper, short fiber asbestos, long fiber asbestos, asbestos woodflour, and mica.

2. Ureas: alpha cellulose filled and electrical grade.

3. Melamines: cellulose filled, asbestos filled, and cotton rag filled.

4. Alkyds: mineral filled.

Inserts—Use of inserts molded into the part during the production operation can in many cases eliminate some expensive post molding operations. Here are several design hints which should be borne in mind when specifying inserts:

1. Always specify metal inserts for small, threaded holes (No. 6 or smaller) when the threads will be subjected to mechanical stress or wear.

2. Avoid long, slender inserts. Molding pressures can deflect them out of position. Delicate inserts are more adaptable to transfer molding than to compression molding. Also bear in mind that very small inserts may cause handling problems in molding, thus raising costs.

3. Brass inserts are generally preferable to steel because the thermal coefficient of expansion of brass more closely approaches that of most plastics.

4. Try to locate plenty of plastics material around the insert in order to hold it securely and to reduce possibility of subsequent failure in service.

5. Threaded male inserts which project from the plastics should be designed so that a slight shoulder of unthreaded metal extends beyond the plastics, preventing plastics material from flowing into the thread.

6. Specify straight or diamond-knurled inserts for maximum gripping strength.

Design suggestions

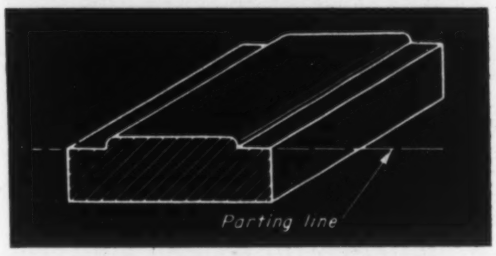


***Fig 1**—Parting line should be in one plane if possible.*

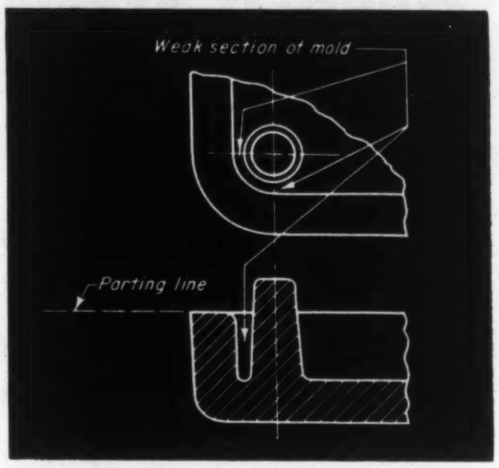


***Fig 2**—Lugs should not be located near corners or edges.*

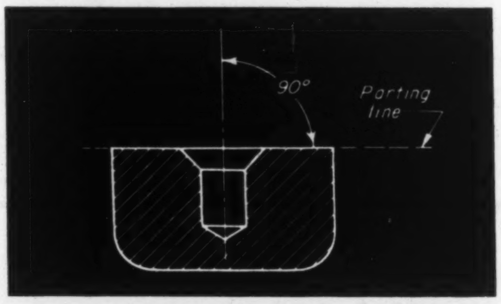


***Fig 3**—Holes should be at 90-deg angle to parting line plane.*

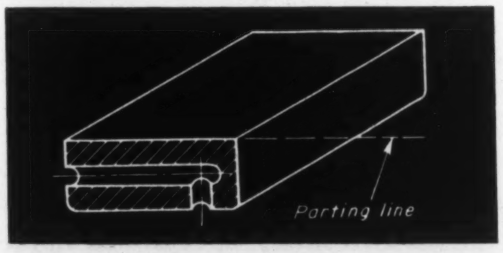


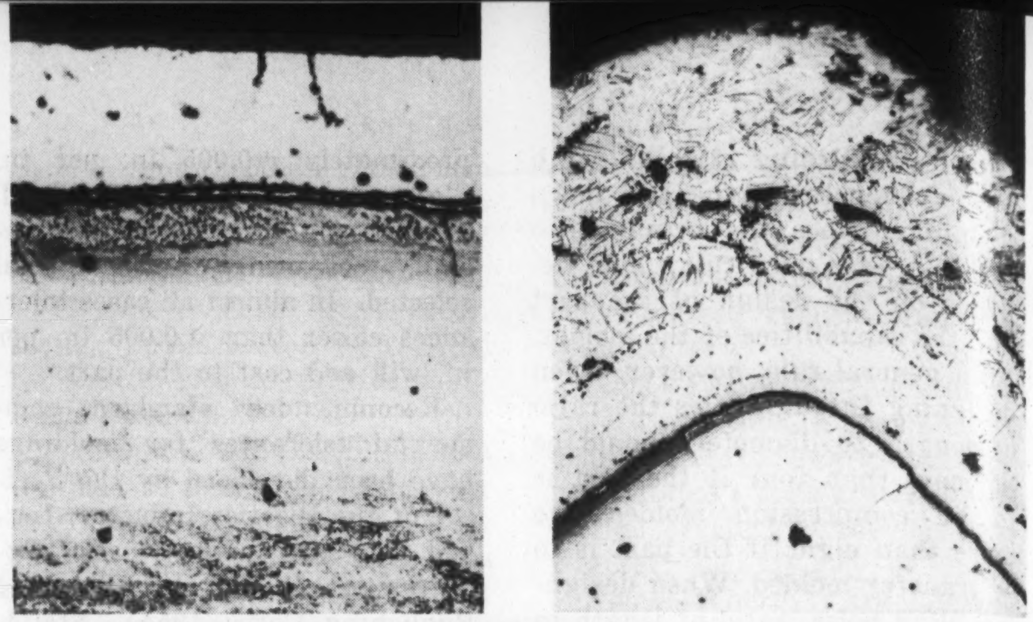
***Fig 4**—Ample support should be provided for pins forming long cored holes.*

Titanium Plating—

Where It Stands Today

Titanium plates that provide high corrosion resistance appear to be destined for commercial applications. Here is a brief rundown of the properties of these desirable coatings and a summary of promising plating processes.

by M. E. Sibert
and M. A. Steinberg,
Horizons, Inc.



***Comparison of single and multiple layer** titanium coatings produced by electrodecomposition plating. Photo left (500 X) shows distinct diffusion band between steel and plate. Photo right (250 X) shows demarcation of layers.*

■ The excellent corrosion resistance of titanium has been demonstrated in many specialized applications. However, because of its comparatively high price, titanium still cannot be used in many commonplace engineering applications. An ideal method of lowering costs appears to be the use of titanium coatings, and much research has been devoted to finding a low cost plating method. To date, titanium plating has not reached the production stage; however, on the basis of recent promising research, commercial use of the coatings appears to be imminent. The purpose of this article is to briefly summarize the major advantages and engineering properties of titanium coatings and to outline significant plating processes.

Corrosion resistance

A titanium coating over a basis metal provides that basis metal with the excellent corrosion resistance of pure titanium. Titanium coatings are smooth, essentially nonporous and inert to a considerable number of mineral acids, alkalis and salt solutions. For this reason they are ideally suited for use in chemical processing equipment. Because of their poor seizing and galling characteristics, they are not suited for use on sliding surfaces where friction is present.

With the exception of aluminum chloride, unstressed titanium appears to be completely resistant to salts (for further information on the corrosion resistance of titanium see "Titanium," MATERIALS IN DESIGN ENGINEERING, Oct '57, p 149). Titanium has shown exceptional resistance to sea water and has not been pitted by stagnation in crevices, under moist crystals and under fouling growths. Similarly, titanium plated ingot iron has shown no signs of corrosion after exposure to a 20% sodium chloride solution for three months at room temperature.

Excellent results have also been obtained with titanium plated ingot iron that has been exposed to acid media. Specimens tested for three months at room temperature have shown only traces of corrosion after immersion in 20% and concentrated nitric acid, 20% and concentrated hydrochloric acid, and concentrated sulfuric acid. In some cases these results differ from, and are somewhat better than, results obtained with solid titanium. For example, sulfuric acid and concentrations of hydrochloric acid above 4% attack unalloyed solid titanium quite rapidly.

Other properties

To date, the mechanical and physical properties of titanium coatings have not been studied extensively. Some measurements, however, have been made on coatings produced by electrodecomposition plating.

Thickness — In general, the thickness that can be obtained in one electrolysis cycle is limited to about 1.6 mils. Thickness can be built up by repeated cycling, and coatings 8 mils thick have been reported.

Hardness—Individual hardness measurements have been made after each one of five successive electrolysis cycles during electrodecomposition plating. Hardnesses (VPN, 25-gm load) of the first to last plates were 119, 167, 340, 383 and 352, respectively.

Adhesion—Bar specimens have been bent 60 deg with no evidence of spalling or flaking of the coating. Also, specimens could be rolled to about 30-40% reduction without fracturing the coatings.

Plating methods

Theoretically, several methods are available for depositing a titanium coating. They include: 1) aqueous electroplating, 2) nonaqueous electroplating in a low temperature electrolyte, 3) fused salt electrodecomposition plating, and 4) fused salt soluble anode electroplating.

Because of the presence of oxygen-bearing solvents, the first two methods are incapable of producing satisfactory titanium coatings. Titanium ions have an affinity for oxygen and tend to form very strong titanium-oxygen bonds. Consequently, attempts to plate titanium from aqueous or other oxygen-bearing media invariably produce deposits of a titanium oxide or hydrated oxide rather than pure titanium.

Electrodecomposition plating

The most promising titanium coatings so far have been obtained by fused salt electrodecomposition plating and by fused salt soluble anode electroplating. Inert anodes such as graphite or platinum are used in electrodecomposition plating and, as its name implies, the process deposits titanium by decomposition of an electrolytic compound. Briefly, the steps in the process can be summarized as follows:

1. Ionization of titanium salts in a suitable melt.
2. Migration of titanium ions under influence of d.c. current.
3. Simultaneous deposition of cation at cathode and anion at anode.
4. Formation of gas at anode and titanium plate at cathode.

During electrodecomposition plating the electrolyte must be replenished to maintain a fairly constant concentration.

Many of the early unsuccessful attempts at electrodecomposition plating resulted from the failure of investigators to realize the importance of using oxygen-free materials and inert atmospheres. Recently, however, satisfactory titanium coatings have been produced at the U.S. Bureau of Standards using a titanium trichloride-sodium chloride-potassium chloride melt, and by Horizons, Inc. using fluoride decomposition processes.

In general, the principles involved in the Horizons process are applicable to all successful electrodecomposition plating processes. This process is essentially an electrolysis of a potassium-titanium fluoride and sodium chloride salt melt which deposits titanium on a cathode. Lithium and potassium chloride salts can also be used instead of sodium chloride. However, sodium chloride has usually been selected since it is readily available in pure anhydrous form and behaves well electrolytically.

For most work a 15-17% concentration of potassium-titanium fluoride in sodium chloride has been used as the melt (fluoride concentrations of 5-25% have also been used successfully). This combination melts at about 1330 F and has good fluidity at the usual electrolysis temperature range of 1560-1740 F.

Most of the actual plating occurs during the early part of the electrolysis cycle. Plating stops after a certain point and continued electrolysis produces a crystalline deposit around the cathode. This deposit can be washed off, however, and the cycle can be repeated to obtain a thicker plate.

Ingot iron and cold rolled steel cathodes in the form of bars, cylinders and truncated cones have been successfully plated. In a typical multiple electrolysis, a 0.246-in. bar was plated at 5.7 v and 95 amp per sq dm at 1670 F using a 16% potassium-titanium fluoride and sodium chloride melt. After five successive plating and washing cycles, total plate thickness on each side of the bar was 8 mils, or 1.6 mils per cycle.

Temperature has a marked effect on the process. Titanium coatings with poor continuity and bad peeling characteristics are produced below 1470 F. However, electrolysis conducted between 1470 and 1650 F always produces a diffusion bond between the titanium and the basis metal. This diffusion bond is largely responsible for the good adhesion that is obtained.

Electroplating

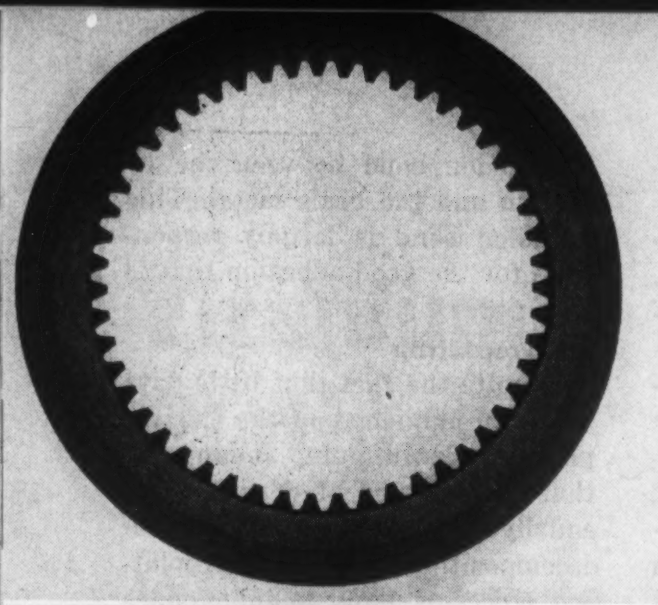
Despite the fact that little data has been published on the electroplating of titanium, it appears that this method of deposition is equally as promising as electrodecomposition plating. Electroplating processes using soluble anodes may employ melts that are similar to those used in electrodecomposition plating, but the ultimate source of titanium is the anode itself. Briefly, the steps employed in electroplating consist of:

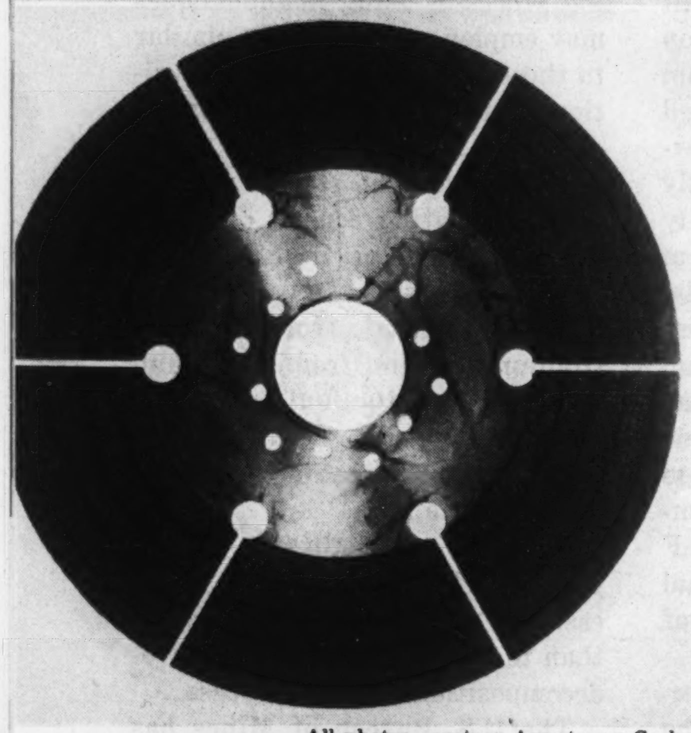
1. Ionization of titanium salts in a suitable melt.
2. Simultaneous formation of titanium solution from anode and deposition of titanium from melt on cathode such that constant titanium concentration is maintained in the melt.

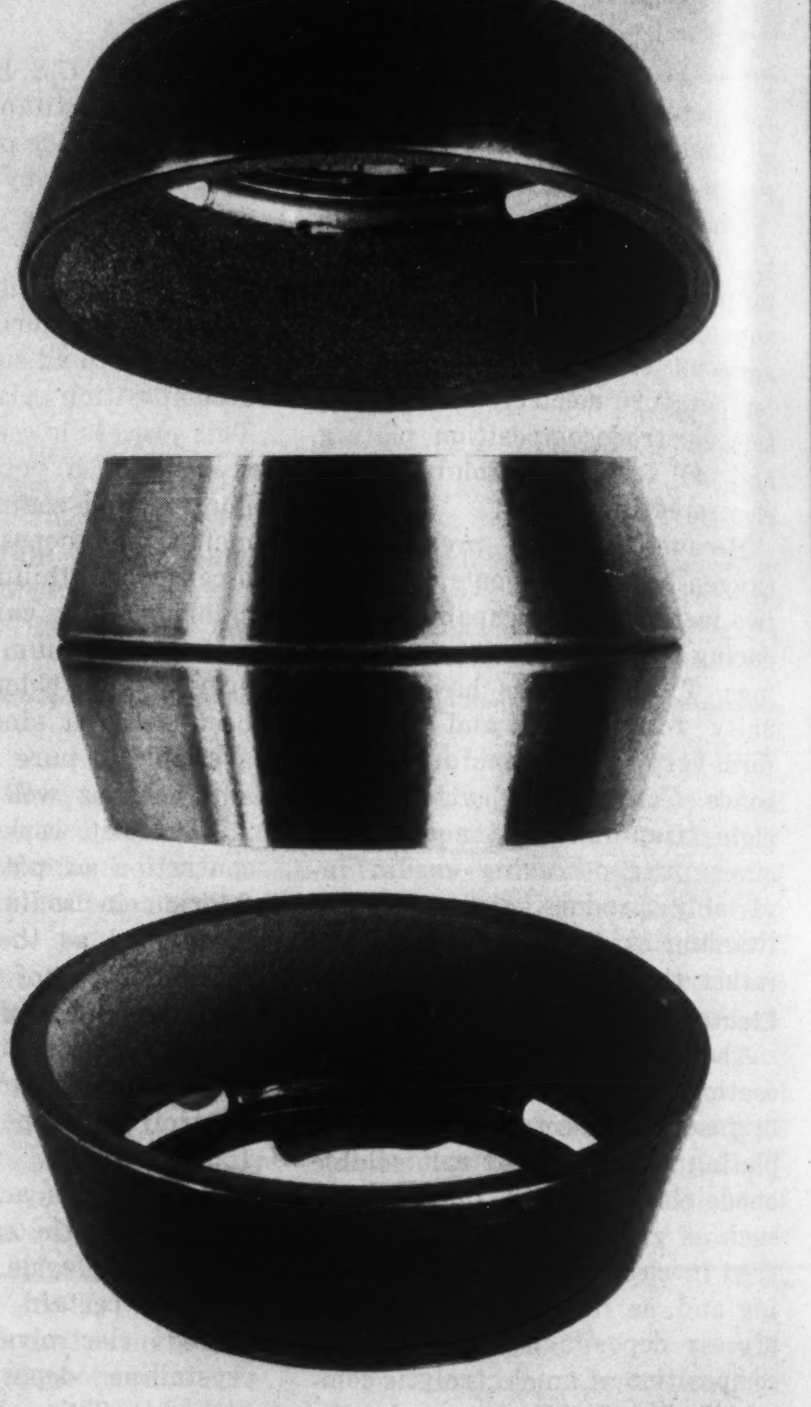
Only the anode has to be replaced in the electroplating process, and process control is simpler than that required for the electrodecomposition plating process.

The U.S. Bureau of Mines has conducted extensive research on soluble anode processes, the most promising results being obtained with titanium trichloride melts. Successful plates have also been reported with magnesium chloride melts. Reduced halide melts have been used to plate titanium on steel, nickel, copper and other metals. In general, the best plates are obtained with melts containing reduced titanium mixtures such as titanium dichloride-titanium trichloride.

Many of the processing variables that apply to electrodecomposition plating also apply to soluble anode plating. Current density is quite important in soluble anode plating and must be controlled for both anode and cathode. Current density must be substantially less at the anode than at the cathode, and for this reason the surface area of the anode must be appreciably greater than the area of the cathode (i.e., the part to be plated).







All photos courtesy Armstrong Cork Co.

***Resilient** cork compounds are used on these clutch parts. **Top**—Automatic transmission clutch plate for automobile. **Right**—Cone clutch for drill or tapper. **Bottom**—Direct drive clutch plate for truck.*

Selecting Friction Materials

PART 2

▸ Resilient and metallic materials
▸ Property comparison data

by Elwin J. Salter,
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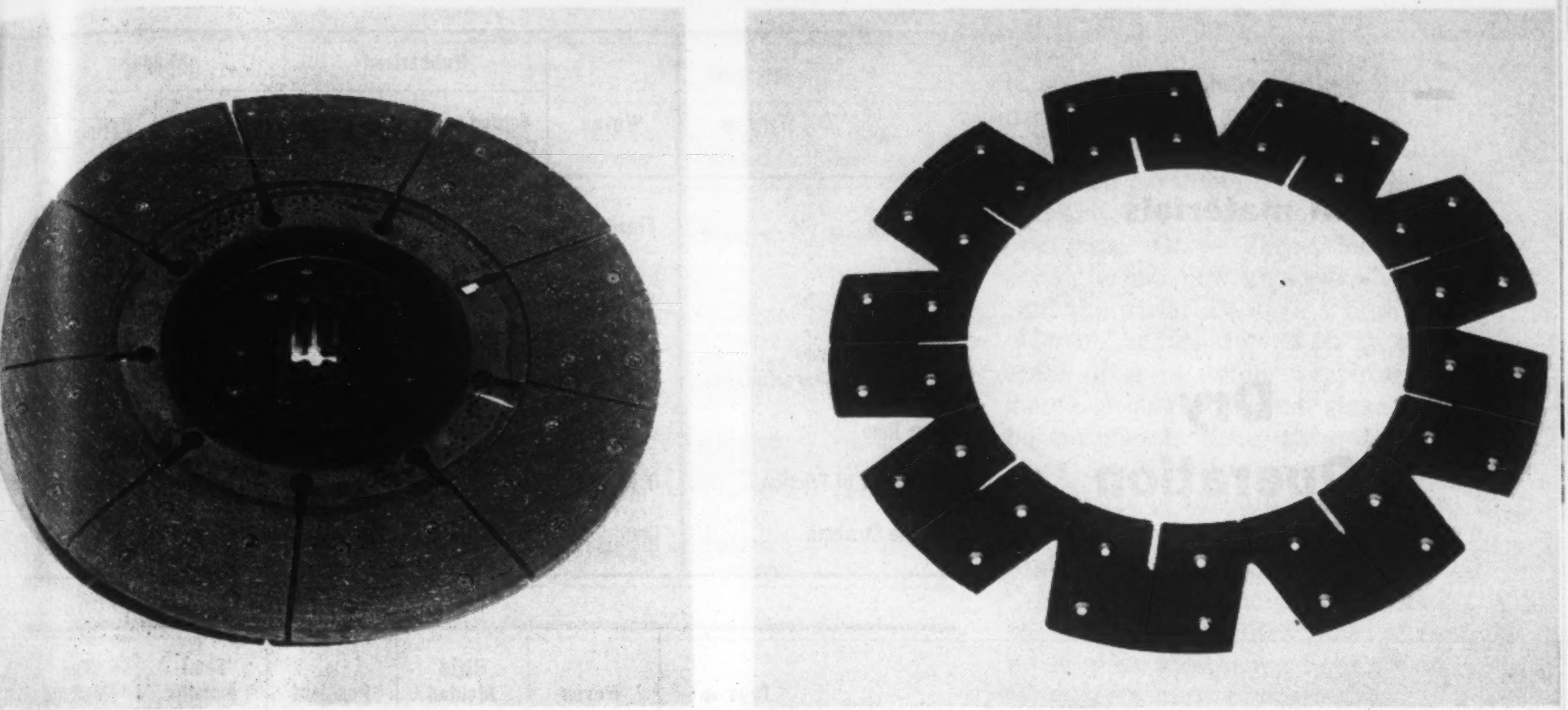
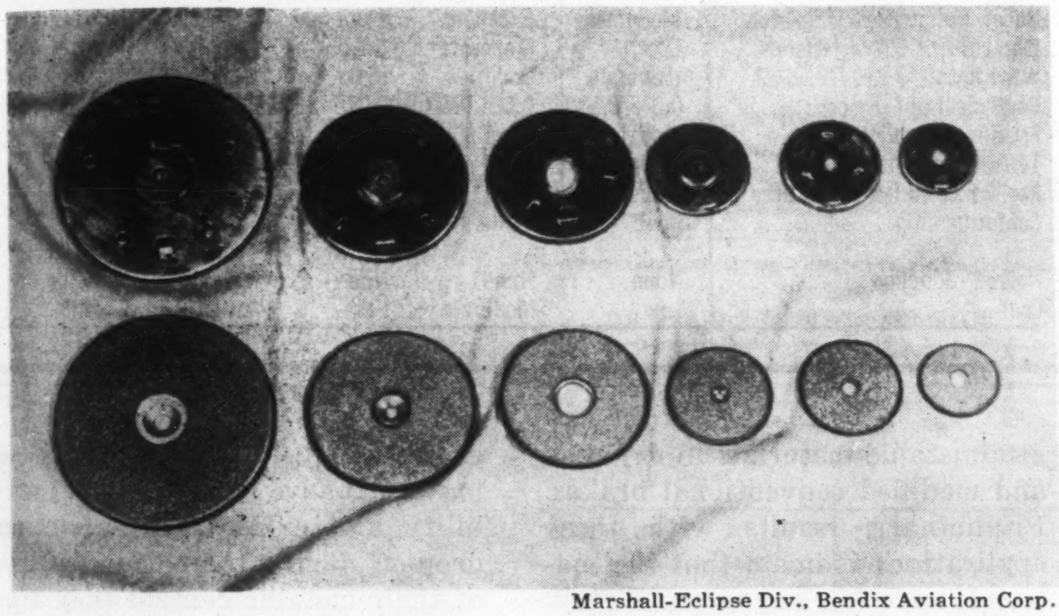
■ This is the second of two articles intended to aid the engineer in selecting friction materials for automotive, industrial and aircraft applications. As pointed out last month (see MATERIALS IN DESIGN ENGINEERING, Oct '57, p 130), a wide variety of friction materials have been made available to meet specific end applications and environments. Selection factors and three of the basic types of friction materials—woven, rubberized and molded—have already been discussed. This article covers the selection of resilient and metallic materials and presents a side-by-side comparison of the





Marshall-Eclipse Div., Bendix Aviation Corp.

Metallic. **Above**—*Semimetallic (left) and full metallic (right) clutch facings are both used on army tanks.* **Left**—*Cerametallic buttons are available in wide variety of sizes for aircraft disk brakes and heavy duty clutches.*

significant engineering properties of all friction materials.

Resilient materials

Resilient materials composed of asbestos, cellulose, or cork compounds plus a bonding agent, are mainly used in oil media. The materials are somewhat porous and produce smooth, quiet operation because of their compressibility and damping action under pressure. They also have the advantage of low cost. Coefficient of friction ranges from 0.075 to 0.130.

Because of their low tensile strength, however, resilient materials have a high wear rate. Wear is also affected by the tendency of these materials to take a permanent set and lose their resiliency. Frictional stability is also poor. A further disadvantage of these materials is their limitation to operation below 400 F, because of the tendency of cork and cellulose to char at this temperature.

Woven friction materials described in the previous article are also quite resilient when operated in oil. The asbestos-cotton yarn provides a smooth spongy action during engagement. These materials have an advantage over other resilients in that they can be operated at higher temperatures, since they contain asbestos and a heat resistant binder. Also, when wire strands are added to the weave the materials can withstand higher unit pressures than cork and cellulose and will not take a permanent set. Coefficient of friction is about the same as that of other resilients—0.075 to 0.130.

Metallic materials

Semimetallic friction materials consist primarily of metal powders (40% min) plus a synthetic resin bonding agent, short asbestos fibers, graphite and friction modifiers. Copper powders are chiefly used because of their good frictional properties; however, lead powders are sometimes used

Selecting friction materials for . . .

Dry Operation

Type ➡	Woven	Rubberized		Molded	
		Folded and Compressed	Coated Yarn	Dry Mix	Extruded
Structure	Flexible	Flexible	Semi-flexible	Rigid	Semi-flexible to rigid
Type of Duty	Moderate to heavy	Moderate to heavy	Moderate	Moderate to heavy	Moderate
Shock Resistance	Good	Good	Good	Excellent	Moderate
Engagement Characteristics	Excellent	Good	Good	Good	Good
Wear Rate	Good	Good	Moderate	Good	Moderate
Coefficient of Friction	0.30-0.50	0.35-0.45	.30-.40	.30-.45	.30-.40
Tensile Strength	Good	Good	Good	Excellent	Moderate

Oil Operation

Type ➡	Woven	Rigid Molded	Resilient	Semi-metallic	Full Metallic
Structure	Flexible	Rigid	Flexible	Rigid	Rigid
Shock Resistance	Moderate	Excellent	Moderate	Good	Moderate
Engagement Characteristics	Good	Moderate	Good	Good	Moderate
Wear Rate	Moderate	Good	High	Good	Excellent
Coefficient of Friction	0.075-0.130	0.065-0.100	0.075-0.130	0.065-0.100	0.050-0.090
Frictional Stability	Moderate	Good	Moderate	Good	Excellent
Tensile Strength	Moderate	Good	Low	Good	Poor
Resistance to Deformation	Moderate	Good	Poor	Good	Moderate
Conformability	Good	Moderate	Excellent	Good to moderate	Moderate
Noise Production	None	None	None	Some	Some
Cost	Low	Moderate	Low	High	High

because of their good lubrication properties at high temperatures.

The semimetallics possess a number of significant advantages including: 1) good frictional stability under severe operating conditions, 2) smooth engagement characteristics when lubricated because of the copper film that forms on the friction surface, and 3) ability to be easily molded in bands, plates, cores and intricate shapes.

These materials are more durable than resilient materials, but less durable than full metallic materials under severe service conditions. The semimetallics cost more than resilient materials and have a low coefficient of friction (0.065-0.100) which tends to become even lower during service. They are mainly used in aircraft applications and in automatic transmissions.

Recent applications have utilized semimetallic materials in dry disk and modified conventional brakes. Preliminary results with these applications indicate that the materials have fair engagement characteristics in a medium friction range. They have also exhibited fair to excellent durability, but noise and cost present major problems.

Full metallic friction materials consist of a sintered metal matrix interspersed with metallic and nonmetallic friction modifiers. The matrix usually consists of a copper-tin bronze, but may also consist of iron, or iron bronze, for lower cost. Since the material has a weak structure it is always bonded to a steel core or backing plate.

Full metallic friction materials have the lowest coefficient of friction (0.055-0.090) of the materials that can be used in oil media (they can also be used in dry environments). However, these materials have good frictional stability and exhibit little friction drop-off during their life. Because of their metallic content they also have a high rate of heat dissipation.

Full metallics are particularly suited for applications requiring a high kinetic energy absorption per square inch and where severe use is accompanied by rapid cycling. Under these conditions the materials have a much lower wear rate than semimetallic materials. This advantage is attributable to a high rate of heat dissipation and the absence of any insulating material such as asbestos or a bonding agent.

Disadvantages of the full metallics are: high cost, weak structure, occasional noisy operation, low coefficient of friction, high specific gravity, and bimetallic warpage when the material is ap-

Molded—continued			Resilient	Metallic		
Wire Back	Sheeter	Millboard		Semi-metallic	Full Metallic	Cera-metallic
Semi-flexible to rigid	Semi-flexible to flexible	Rigid	Flexible	Rigid	Rigid	Rigid
Moderate	Light to moderate	Light to moderate	Light to moderate	Moderate	Moderate to heavy	Heavy (high temp)
Moderate	Moderate	Moderate	Good	Moderate	Moderate	Poor
Good	Good	Good	Excellent	Moderate to good	Good	Poor
Moderate	Moderate	Moderate	Poor	Moderate	Excellent	Fair to excellent
.30-.40	.30-.40	.30-.45	—	Medium	Low to medium	Low to high
Moderate	Moderate	Moderate	Poor	Moderate	Poor to moderate	Poor to moderate

plied to the steel backing plate. Also, engagement characteristics are not as good as those of the semimetallics.

Like the semimetallics, full metallic materials have recently been used for dry disk and modified conventional brakes. They have shown excellent durability at high temperatures and good engagement characteristics.

Cerametallic friction materials are composed of ceramic particles in a metallic matrix. The materials are capable of operating at 2000 F (dry) and were primarily developed for high temperature aircraft applications. The materials are also used on large tractor clutches and hold promise for use on brakes for large commercial vehicles.

To overcome their inherent weakness and brittleness, the ceramics are placed in a metallic matrix which serves a twofold purpose by 1) supporting the ceramics, and 2) conducting heat away from the surface. Additional support is provided by placing the ceramic-metal matrix in a metal holder or receptacle.

The excellent heat absorptivity of cerametallics is due to compounding ingredients that have higher density, higher specific heat and higher thermal conductivity than those used in more conventional linings. Because of their high heat capacity, these materials have better resistance to fading than any other friction materials. Since the cerametallics must be heat treated during manufacture at temperatures above the soaking temperatures encountered during use, they are also capable of withstanding higher temperatures than full metallic linings.

Some of the earlier disadvantages of cerametallics have been eliminated through improved compounding. Glaze formation, for example, can now be controlled so that the materials have a high coefficient of friction that is constant over a wide temperature range. However, some glaze can be beneficial, since glaze formations and hard ceramic particles contribute to the substantial wear resistance of the cerametallics at high temperatures.

Some of the principal objections to the cerametallics are their noise, poor engagement characteristics and high cost. Because of the material's rigidity, any surface irregularities tend to promote poor engagement; this is especially evident at high temperatures. High cost is due to special compounding ingredients and the method of manufacture.

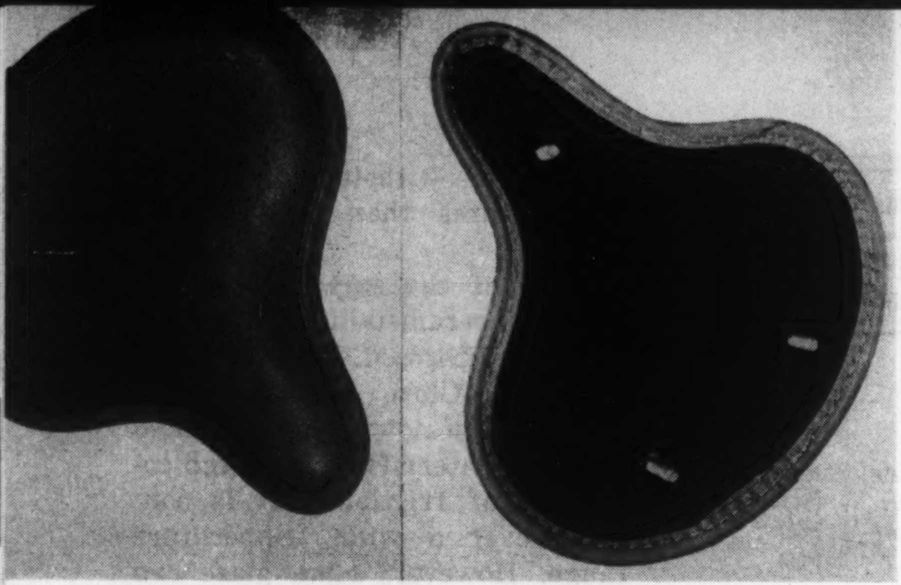
AVAILABLE SHAPES AND SIZES OF NONMETALLIC FRICTION MATERIALS

Type ↓	Shape	Maximum Size		
		Width, in.	Thickness, in.	Diameter, in.
Woven	Annular ring, flexible roll	12	1½	Any
Rubberized				
Folded and Compressed	Annular ring, flexible roll	8	1¼	Any
Coated Yarn	Annular ring	—	¼	18
Molded				
Dry Mix	Rigid segment	20	1½	Any
Extruded	Semiflexible roll, rigid segment	5	½	Any
Wire Back	Semiflexible roll, rigid segment	5	½	Any
Sheeter	Annular ring, flexible roll	50	5/16	Any

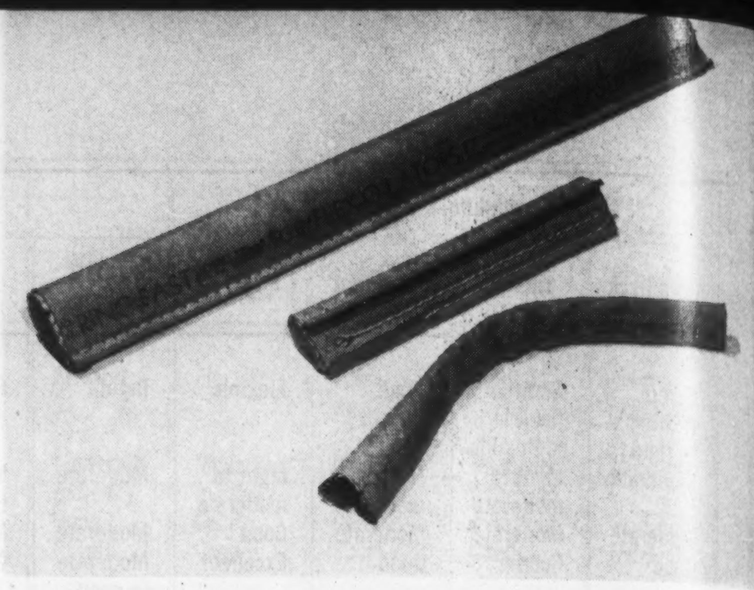
COMPARISON OF FRICTION MATERIALS FOR AUTOMOTIVE TRANSMISSIONS[a]

Type ↓	Coefficient of Friction	Maximum Operating Temperature, F	Principal Applications
Woven	High	400	Transmission plates
Molded	Medium	450	Transmission bands
Resilient	High	550	Transmission bands, plates and cones
Semimetallic	Medium	450	Transmission bands and plates
Metallic	Low	700	Transmission plates

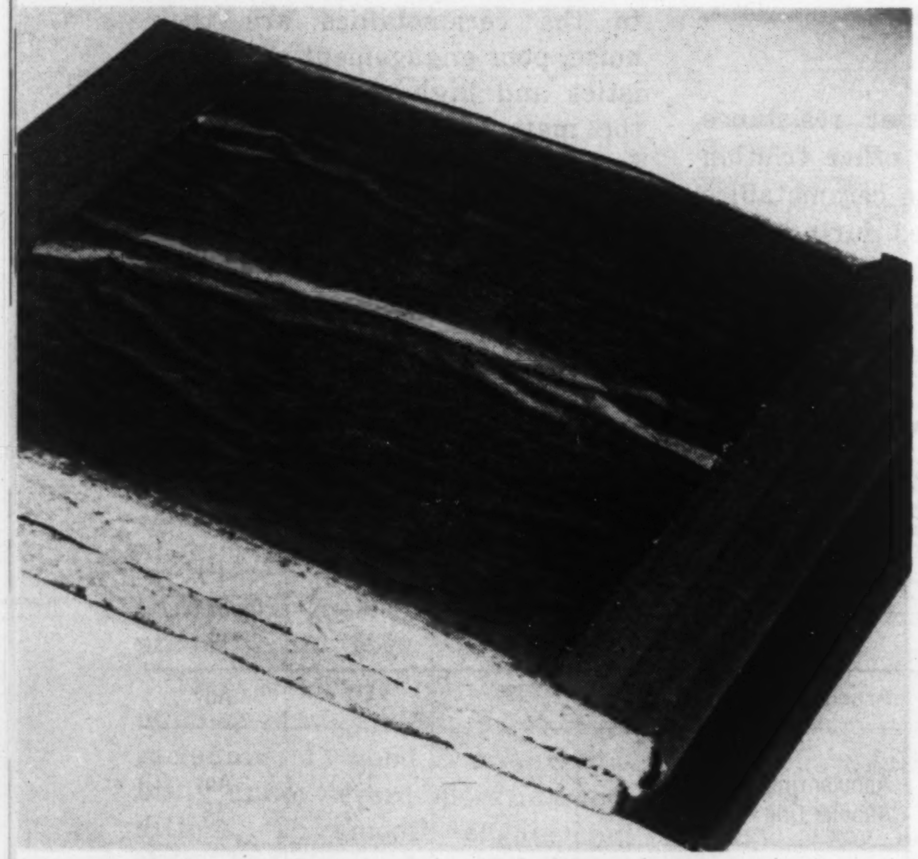
[a] For use in oil media.



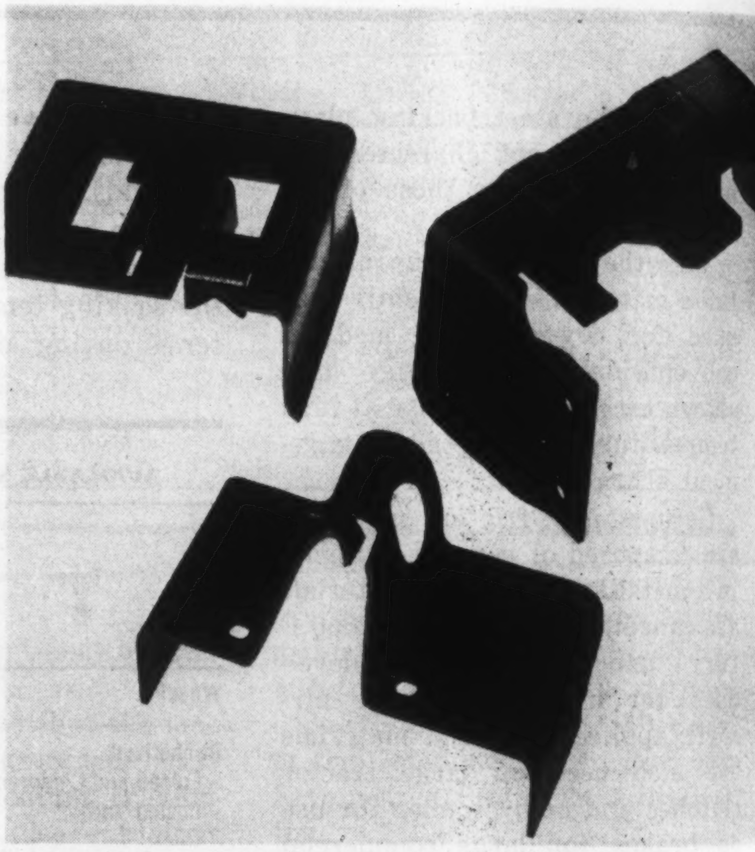
BACKING MATERIAL— *Use of die-cut sheets as a backing material for bicycle seats permits vinyl-coated fabric to be sewn to backing, providing low cost, attractive seat.*



FURNITURE MANUFACTURE—*Cross-creped kraft is used to replace burlap as covers for these edge roll bindings used in furniture manufacture.*



INSULATION COVER—*When cross-creped kraft is used as a cover for insulation batts, batts can be reused.*



POSTFORMABLE LAMINATES—*The compound curves in these postformed, high pressure plastics laminates are made possible by use of cross-creped kraft as the reinforcement.*

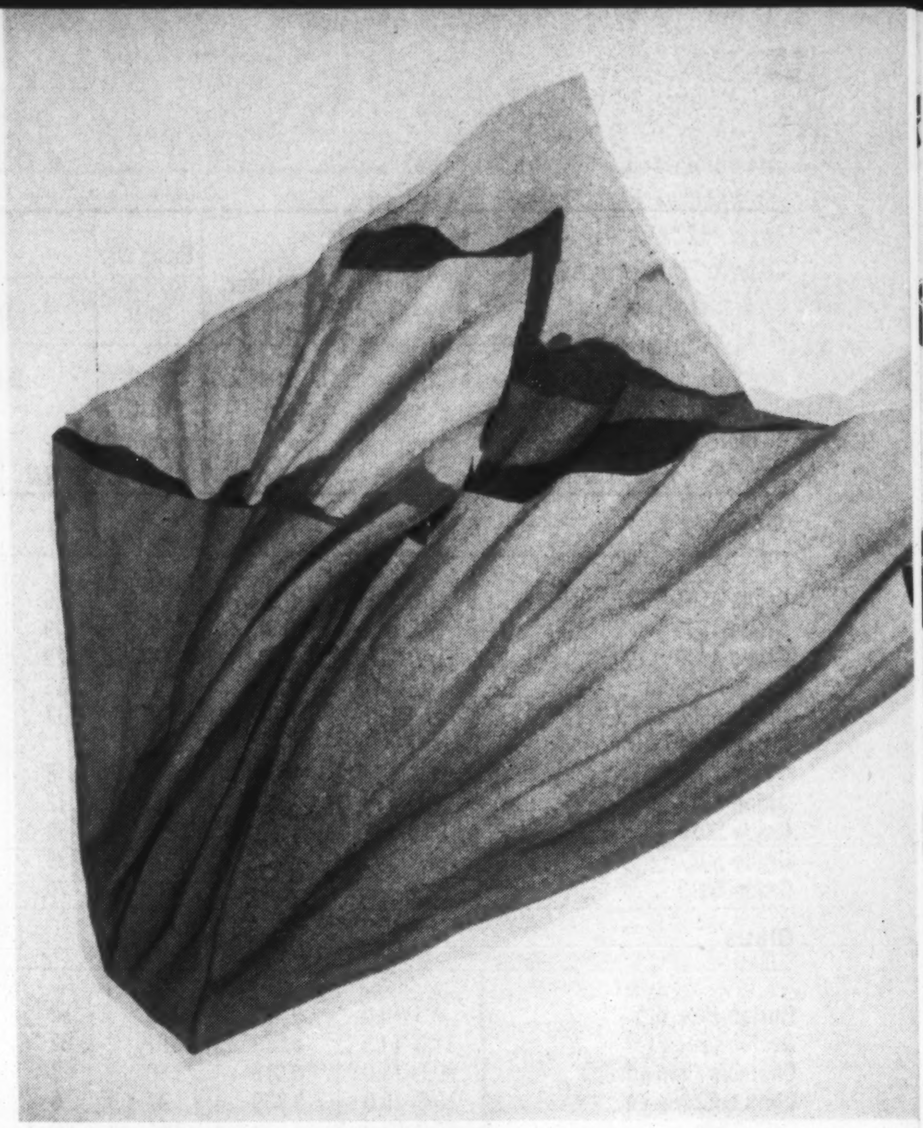
These are some of the industrial uses of . . .

Cross-Creped Kraft

—A New Kind of Paper

by V. R. Piper, *Technical Director, Cincinnati Industries, Inc.*

DECORATIVE SHEET—*Printed designs such as these knotty pine and texture finishes can be easily applied.*



IMITATION CHAMOIS—*Treated with appropriate resins, cross-creped kraft can be used like chamois and will withstand many soakings in water.*

■ Take kraft paper, crepe it in one direction, then cross-crepe it in the opposite direction and you have a stretchable paper-base material called X-Crepe. When stretched, cross-creped kraft paper retains the elongation and does not return to its original dimensions. The cross-creping also provides a soft texture, and increased edge tear strength and sewing strength.

Cross-creped kraft can be slit, die-cut in any shape, or fed from rolls to high speed machinery. Since it is not a woven material it will not ravel. It is pliable and can be formed to simple or compound curves by conventional methods including vacuum or air pressure forming. It can also be drawn or molded. It can be glued with conventional industrial adhesives, or heat sealable types can be specified.

Cross-creped kraft is available in several weights, based on the weight of the kraft paper. Base weight of the kraft paper varies from 40 to 90 lb. Elongation on stretching can be made to vary between 15 and 60% longitudinally, and 15 and 45% laterally.

The two basic types of cross-creped kraft are type A, lami-

How the Paper Is Made

Most creping processes consist basically of bonding paper to a smooth surface and "doctoring" or scraping it off with a knife. The physical action of the knife working against the adhesive bond between paper and surface causes the formation of small pleats or folds in the paper. In general, the stronger the bond between paper and surface, the finer will be the pleats or folds.

Cross-creped kraft, or X-Crepe, is produced by a patented process in which kraft paper is bonded to a large cylinder that rotates against a knife mounted against the cylinder at an angle of 45 deg to the direction of rotation. The knife peels the paper from the cylinder, forming very fine pleats in one diagonal and imparting stretch in that diagonal direction as well as in both the machine and cross-machine directions.

The material is then adhered to a second cylinder which is equipped with a knife mounted at a 45-deg angle opposite to that of the first knife. Rotation of the cylinder results in similar pleats being formed on the opposite diagonal, and imparts stretch on the second diagonal as well as additional stretch in the machine and cross-machine directions.

COMPARISON OF PROPERTIES—X-CREPE VS

Material	Approx Cost, ¢/sq yd	Caliper	Basis Wt, lb/3000 sq ft	Tensile Strength, lb Dry		Tensile Strength, lb Wet		Stretch, %		Elmendorf Tear Strength, gm	
ASTM	—	D 645	D 646	D 828		D 829		D 987		D 689	
TAPPI	—	T411	T410	—		—		—		T414	
Dir of Loading[b]	—	—	—	CMD	MD	CMD	MD	CMD	MD	CMD	MD
X-Crepe											
Grade 4501	6.0–8.5	0.009	71	6	9	0	0	30	30	270	220
Grade 4506	7.5–10.0	0.015	105	9	14	0	0	30	30	400	320
Grade 4506-8.10 (2)	17.0–20.0	0.014	137	29	34	3	4	38	34	576	544
Grade 4506-31	14.5–17.5	0.015	110	15	36	6	16	28	20	386	256
Grade 4506-H-LX-5 (2)	18.5–22.0	0.018	145	17	35	2	4	46	48	816	656
Grade 4506 (cushioned style No. 2)	8.0–10.5	0.090	105	8	12	0	0	30	30	320	304
Grade 4512	9.5–13.0	0.022	155	12	18	1	2	30	30	600	500
Grade 5032	13.5–18.0	0.024	331	30	37	10	14	15	20	812	642
Grade 5037	14.5–19.0	0.025	220	38	44	4	5	25	35	950	850
Grade 6013	37.5–48.5	0.040	450	70	95	6	8	25	35	2000	1900
Others											
Burlap (7½ oz)	8.5–10.0	0.023	145	52	58	46	50	6	4	—	—
Burlap (10 oz)	11.0–12.5	0.023	187	62	66	51	52	7	4	—	—
Chamois (nonwoven)	20.0–25.0	0.012	86	3	38	3	22	55	8	520	244
Cloth (nonwoven)	10.0–15.0	0.009	37	6	13	2	4	4	3	568	388
Drill Cloth	50.0–60.0	0.018	154	56	106	52	100	12	24	2960	1920
Osnaburg-Grey Goods	30.0–35.0	0.018	117	43	70	38	64	22	8	—	—
Sheeting (light)	10.0–20.0	0.005	31	4	19	3	16	10	6	—	—
Sheeting (medium)	25.0–35.0	0.011	82	40	44	38	40	15	14	1408	1188
Rubber Saturated Paper											
20 Pt	15.0–18.0	0.020	143	14	30	5	9	30	15	708	590
40 Pt	31.0–34.0	0.040	285	15	26	4	7	48	28	1016	842
50 Pt	39.5–42.5	0.050	346	19	33	8	14	58	27	1600	1184

[a] Speeds of tests are: Dynamic—32.2 ft/sec/sec (gravity); Scott—12 in./min.

[b] CMD=cross-machine direction; MD=machine direction.

Work and Tear Tests

In the accompanying table the ASTM and TAPPI test methods used to obtain the data are indicated. However, three of the tests may be unfamiliar to the designer or engineer:

Scott work test

Values are calculated work figures determined by the area described by a stress-strain curve as recorded on a Scott tensile and stretch machine. In this table, the area, converted to in.-lb of work, is divided by the area of the test piece; resulting values are expressed as in.-lb per sq in.

Dynamic work test

Test piece of 2 x 12 in. is held between clamps so as to present a test area of 2 x 10 in. in the horizontal plane. A known weight (lb) is dropped through a known distance (in.) so as to strike the test piece with an impact blow across the center. The test value for any piece is determined as the greatest number of in.-lb the test piece will withstand without breaking in any one drop, divided by the area of the test piece. The result is expressed as in.-lb per sq in.

Trapezoidal tear test

A rectangular piece of material is marked, from edge to edge, with two nonparallel lines. Distance between the two lines is 1 in. at one edge and 4 in. at the opposite edge. The sample is then clamped in a Scott tensile machine (jaws set at 1 in.) so that the two lines are parallel (i.e., material closest to edge where lines are 4 in. apart is slack and billows out, while area at edge where lines are 1 in. apart is in vertical plane with jaws). Tension is applied to begin tear at 1-in. side, and tearing force, or trapezoidal tear strength, is measured in pounds.

nated with asphalt, and type N, which has no asphalt. With these two basic types as a starting point, over 200 specialized types of cross-creped kraft have been made. Each type is designed for a specific kind of service, and has physical, chemical or thermal properties that have been modified or enhanced. These modifications are obtained by treatments such as surface coating, impregnation or lamination. Color can also be added.

Physical properties

The accompanying table compares characteristics of 10 types of cross-creped kraft and 11 other

COMPETITIVE MATERIALS

Bursting Strength (Cady), psi	Work, in.-lb/sq in.[a]				Porosity (Gurley), sec/400 cu cm	Trapezoidal Tear Strength, lb	
	Dynamic		Scott				
D 774 T403	(see box) —		(see box) —		D 726 T460	(see text below) —	
—	CMD	MD	CMD	MD	—	CMD	MD
55	1.0	1.6	1.1	1.8	3	0	0
70	1.2	2.1	1.1	2.5	3	4	2
114	4.6	5.8	4.5	6.8	120	14	13
110	1.5	2.5	2.6	4.7	6	5	4
93	2.5	6.0	2.8	7.2	16	27	15
60	0.9	0.9	1.0	1.8	2	2	1
95	2.1	3.1	2.2	2.8	6	5	4
122	4.4	4.6	4.4	4.8	>600	10	7
140	5.7	8.3	5.4	9.6	80	14	17
260	12.5	17.5	13.0	17.2	195	36	41
160	1.1	1.4	1.0	1.2	0	17	9
210	2.7	3.2	1.8	2.8	0	29	14
81	1.1	1.4	0.9	1.5	0	2	0
40	−0.1	0.2	−0.1	0.2	0	0	0
180	1.9	6.5	1.8	7.8	0	34	7
180	2.3	3.0	2.4	2.1	0	10	10
55	−0.1	0.4	−0.1	0.4	0	0	0
140	0.7	1.4	1.1	1.4	0	3	0
102	2.5	1.5	3.1	3.3	5	7	5
110	4.0	3.0	4.8	5.6	4	12	12
150	6.0	3.5	10.7	7.3	5	19	27

competitive materials, similar in nature and type of end-use. Caliper is determined by number of plies of material, thickness of laminating coat, and base weight of kraft paper. Caliper may range from 0.009 to 0.095 or greater. The final product can be made with rigidity ranging from extreme flexibility to board stiffness.

Tensile strength, though always good when the paper is dry, can vary widely when the paper is wet. Comparisons in the table are made in machine direction (MD) and cross-machine direction (CMD). Single ply, N type materials have very little wet tensile strength unless given special treatments. Dry strength ranges from 6 lb CMD and 9 lb MD to 70 lb CMD and 95 lb MD. In comparison, strength of drill cloth can exceed 95 lb MD but does not exceed 70 lb CMD. Other cloth materials tested do not reach into this strength range.

Elongation on stretching remains high even when certain saturants, laminations or surface treatments are applied. As shown in the accompanying table, 50-pt rubber-saturated paper stretches more CMD than MD. Cross-creped kraft maintains a balanced stretch which can be controlled as desired, i.e., elongation on stretching may be the same in both CMD and MD, or stretchability in one direction may be made to exceed that in the other direction. The actual balance in stretchability should be determined by specific design requirements.

Edge tear strength ranges from 270 gm CMD and 220 gm MD to as high as 2000 gm CMD and 1900 gm MD. Of the cloth materials tested, only drill cloth approaches the higher values.

Bursting strength, measured on the Cady standard, ranges from 55 to 260 psi, indicating the amount of bursting load that can be withstood by the material either during fabrication or in end service.

Porosity of cross-creped kraft can be either high or low, depending on design requirements. With the Gurley test as a basis, materials can be specified that require only 3 sec or as long as 10 min, for 400 cu cm of air to pass through.

Other properties

Service temperature—Although the normal service temperature range of cross-creped kraft paper does not extend beyond about 300 F, the material is usable at temperatures as high as 400 F. Above 400 F scorching may occur. Also, as moisture is driven from the material at elevated temperatures some embrittlement may occur. No data are available on the effect of cold on the material, although it has been successfully used in packaging for all types of climatic conditions.

Chemical properties — Cross-creped kraft is obtainable with a range of chemical characteristics. Materials are available with neutral pH characteristics, or they can be made acidic, or resistant to greases, oils or flame. Some types can be made to absorb certain types of chemicals. In general, the materials have excellent aging properties.

Treatments

Cross-creped kraft is available with three basic types of treatments: 1) treatments which change surface characteristics, 2) impregnations which change the characteristics of the entire sheet, and 3) laminations which can change the over-all structure of the material. In addition to the specific design characteristics for which the treatment is applied, the "hand" or feel of the material is often changed. The treated material may be soft and pliable or extremely rigid.

Surface treatments — Surface treatments that can be applied include embossing and coating. In embossing, the material is dimpled to achieve a cushioning effect. Nonskid cross-creped kraft is produced by applying a rubber latex on the tip of each dimple. In coating, solid colors as well as decorative patterns can be printed on the material. Color can be added at the paper mill or during the creping operation. Combination effects can be obtained by embossing after printing.

Impregnations — Impregnations can provide a variety of end physical properties. Impregnants that can be used include natural or synthetic resins, petroleum products and other chemicals with alkali or acid bases. Wet strength is improved by impregnating with resins that allow the material to shed water, or be soaked in water without disintegrating. Impregnations can also provide resistance to fungi or flame. Scents or oils can be added if desired.

Laminations—Materials to which cross-creped kraft has been laminated successfully include films or sheets of polyethylene, polyethylene terephthalate (Mylar), polystyrene and vinyl. These can be used to provide sandwich materials of various constructions, e.g., a layer of film, a layer of cross-creped kraft, another layer of film and another of cross-creped kraft. End design requirements determine the specific construction and material used.

Other combinations are obtainable by laminating several types of cross-creped kraft. For example, a resin-impregnated type can be laminated to one without resin, or a film-laminated type can be laminated to a resin-impregnated type. Bulk can be added as desired by laminating several plies of material.

Applications

Though the new paper material has definite limitations, its potential applications have not been fully explored. The following types of applications are typical of those satisfactorily developed to date:

Backing material—Used as a backing material, cross-creped kraft permits the production of custom stitched bicycle seats for about the same price as that of unstitched seats. The seats consist of a vinyl coated fabric, padding and a metal core. In manufacturing the seat, die-cut sheets of cross-creped kraft, vinyl coated fabric and padding are all laid into a forming press with the preformed metal core. The materials are then stamped into a saddle "sandwich." The combination is then stitched and trimmed in one operation, and a final stitching puts an attractive binding around the edge.

A specially developed grade of the paper-base material is now used for trim backing on automotive quarter panels. The formability of the material permits it to be drawn tightly around complex curves before it is glued to the body. Felt riser pads are glued to the material and the upholstery sewn between the strips. Where heat sealing can be used instead of sewing, another special grade of the material is used.

Furniture manufacture—In furniture manufacturing, the material is used for covering fabricated parts. It is replacing burlap because of burlap's unstable cost and supply situation. Although cross-creped kraft meets standards of strength and flexibility, the machines designed for burlap have to be redesigned for handling the paper-base material. Use of the material has resulted in faster production and long range savings. The parts can be bent neatly to form square corners without mitering. They can be smoothly formed for curved chairs, modern sectionals and other types of furniture. Wire hog rings are attached through the cross-creped kraft.

Ducting—The material is used to replace rubber coated cloth in flexible automotive heating ducts. It is treated with wax to shed water and keep permeation by hot air to a minimum. The material is also used for welting and windcords.

Postformable plastics laminates—Cross-creped kraft is used as a reinforcement in postformable grades of high pressure plastics laminates. During the postforming process, the kraft stretches to follow the contours of the curve, expanding on one radius and compressing on the other as required.

Packaging—Packaging is one of the major applications for the material. The asphaltic waterproof type is used in case liners for overseas packaging. For this application, the material provides toughness, stretchability and resistance to moisture and moisture vapor. Cross-creped kraft is also used as a cushioning material for packaging and shipment of delicate electronic parts.

Other uses—Other applications for the material include:

1. A moisture barrier in some types of telephone switchboard cables. The material stretches over sharp bends and remains waterproof.

2. A covering for insulation batts used for outdoor concrete construction. Such batts are applied around freshly poured concrete to prevent freezing at low temperatures. The material protects the batts and permits them to be re-used.

3. A rug underlay. Cross-creped kraft is used to reinforce the rubber, which provides an antislip surface.

4. Imitation leather. With an appropriate surface coating, cross-creped kraft provides an excellent imitation leather. The material has the necessary high edge tear strength and a remarkably leather-like hand.

5. Imitation chamois. When treated with an appropriate resin and moistened, the material resembles chamois and can be used as such.

How to Get More Out of Type 410 Stainless Steel

by **Fred J. Poss**, *Westinghouse Electric Corp.*

■ Users of type 410 stainless steel seldom get full value out of this versatile material because they do not heat treat it properly. Many problems could be avoided by following two rules:

1. In hardening, do not quench in oil; either select a material of known high hardenability and use straight air cooling, or martemper in a hot salt bath.
2. In annealing, do not furnace cool; use isothermal annealing to get the softest possible structure.

The difficulties encountered in heat treating type 410 can be attributed to its wide range of permissible compositions. A primary problem is the broad range of carbon permitted. Type 410 is a martensitic steel and yet carbon, the most effective hardener and strengthener, has wider limits (0.08-0.15), percentagewise, than the plain carbon steels. Nitrogen, although not specified, is almost equal to carbon as a hardening agent and is usually present in significant quantities. Briefly, a specimen high in ferrite formers (chromium, silicon) and low in austenitizers (carbon, nitrogen, nickel) may have very different mechanical properties than when the reverse is true.

Hardening and tempering

Type 410 is a borderline air hardening steel. Either very deep or shallow hardenability may be found, depending on the balance of critical elements. Curves from various sources show that the 1350 F transformation may begin at times from 30 sec up to several minutes. Obviously, no single hardening heat treatment can cover all shapes, sizes, and compositions of type 410 parts and give consistent results.

Oil quenching a large and/or complex piece will develop full hardness, but the work may crack, distort or fail prematurely in service. Straight air cooling may not be fast enough to give the necessary hardness if the stainless steel has fast 1350 F transformation properties. There are two solutions: select a material of known high hardenability for straight air cooling, or martemper by quenching in salt from the hardening temperature. The salt bath is maintained at temperatures from 800 to 1000 F (Ms for type 410 is around 650 to 700 F). When the work reaches salt temperature (5-10 min), remove, air cool and temper. This method gives lowest residual stress and distortion with maximum hardness and strength. Tempering at successively higher temperatures reduces stress; up to 900 F type 410 shows no reduction in hardness or strength.

A comparison of hardness and strength properties after air cooling and oil quenching of type 410 parts is shown in Fig 1. The oil quenched parts were heat treated ½ hr at 1850 F and quenched in an oil bath at 150 to 200 F. The air cooled specimens were heat treated ½ hr at 1850 F and air cooled at a maximum of 200° F per hr. The graph shows that the hardness values of air and oil quenched specimens are practically superimposed. However, impact strengths of the two heat treated steels vary greatly; the impact strength of air hardened specimens remains relatively constant at temperatures up to 850 F, whereas the impact strength of oil hardened specimens is lowered when they are tempered at temperatures over 650 F.

Annealing

When annealing type 410 stainless steel parts to improve machinability, the softest structure (Rockwell B 75-80) is produced by isothermal annealing for 2 to 3 hr at temperatures of 1350 to 1400 F until austenite transformation is complete. The directive "furnace cool from austenitizing temperature" does not work with type 410. Type 410 compositions having deep hardening properties may harden appreciably with uncontrolled furnace cooling.

The curves in Fig 2 show the effect of cooling rates on transforming type 410 stainless steel from austenite to martensite structures. Note the absence of transformation at 1350 F on furnace cooling and on cooling at 400° F per hr. The end result here is a brittle, untempered martensite stainless steel that is unfit for any critical application.

Fig 1—*Izod impact strength and Rockwell C hardness of type 410.*

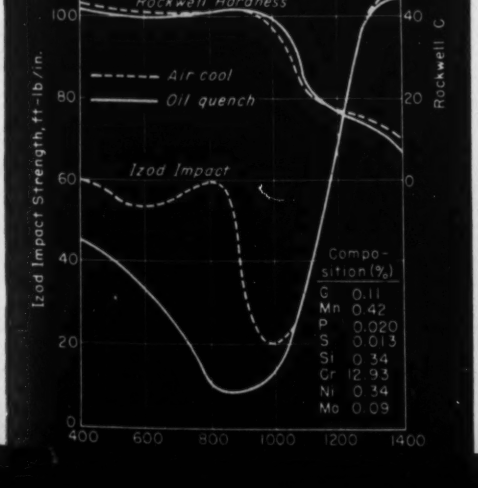
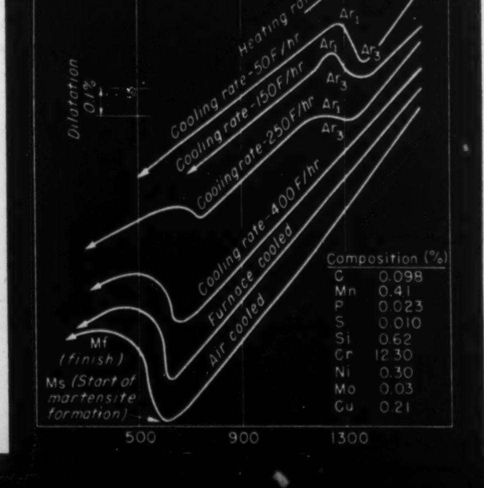


Fig 2—*Effect of cooling on type 410 stainless steel.*



References

ASM Trans, p 794 (fig 4), vol 45, 1955.

Atlas of Isothermal Transformation Diagrams, U.S. Steel Corp., Pittsburgh, Pa.

Heat Treatment of Enduro Stainless Steels (fig 2), Republic Steel Corp., Cleveland.

Simon, A., "How Tempering Affects Corrosion Resistance of 12% Chromium Steel," MATERIALS & METHODS, July '54, p 138.

Three Manganese Alloys

have useful thermal and elastic properties

An unusual combination of properties is leading to new applications of these relatively unknown alloys.

by John L. Everhart,
Technical Editor, Materials in Design Engineering

	1	2	3
Alloy ➜	Mn 80 Cu 20	Mn 72 Cu 18 Ni 10	Mn 50 Fe 45 Al 5
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.259	—
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	4.9	4.9	—
Coef of Ther Exp (68 F), per °F	11.1×10^{6}	14.2×10^{6}	4.4×10^{-6}
Specific Heat (68 F), Btu/lb/°F	—	0.126	—
Electrical Resistivity (68 F), microhm-cm	149	174	120
Modulus of Elasticity in Tension, psi	13.5×10^{6}	18×10^{-6}	—
Modulus of Rigidity, psi	4×10^{-6}	—	—
Poisson's Ratio	0.7	—	—
MECHANICAL PROPERTIES			
Tensile Strength, 1000 psi			
Quenched	68	—	—
Cold Rolled	130[a]	115[b]	—
Yield Strength, 1000 psi			
Quenched	24	—	—
Cold Rolled	115[a]	95[b]	—
Elongation (2 in.), %			
Quenched	35	—	—
Cold Rolled	9[a]	6.5[b]	—
Reduction of Area (quenched), %	49	—	—
Hardness, Rockwell			
Quenched	B55	B96	—
Cold Rolled	—	—	B50
Fatigue Strength (quenched, 10^8 cycles), 1000 psi	17	—	—

[a] Cold rolled 30%. [b] Cold rolled 50%.

■ Commercially pure manganese, available as the electrolytic grade, has no known engineering applications because it is hard and brittle at room temperature. However, alloying with certain metals in suitable proportions yields ductile materials. Among the high manganese (50% or more Mn) alloys that have been investigated, three groups have achieved commercial importance. These are:

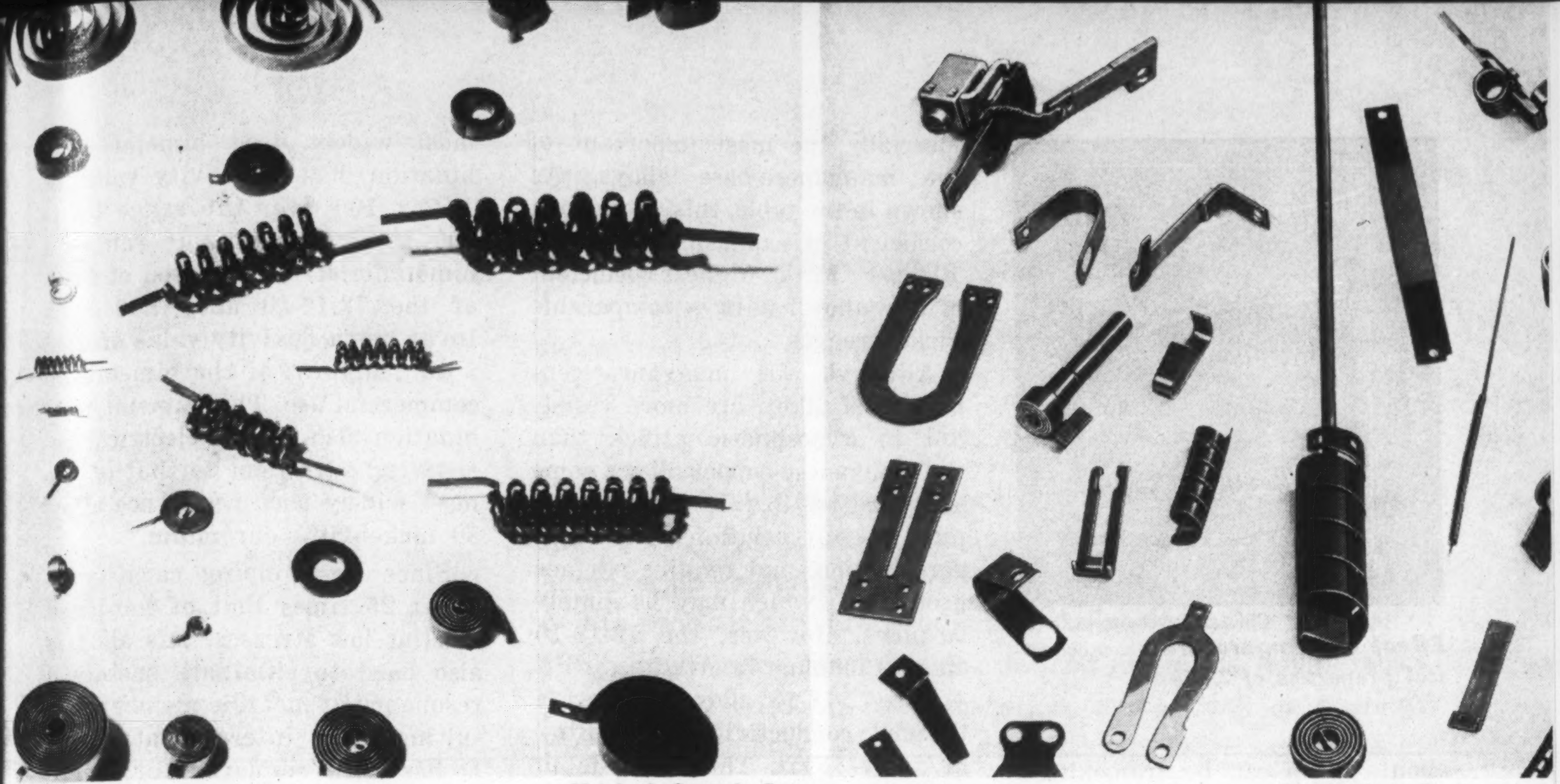
1. Manganese-copper alloys containing 60 to 80% manganese.
2. Manganese-nickel-copper alloys containing 60 to 80% manganese and 10 to 20% nickel.
3. Ternary alloys containing 50 manganese, 45 iron and 5% of aluminum, cobalt or nickel.

1. Manganese-copper

Manganese-copper alloys containing 60 to 80% manganese have high electrical resistivities and low temperature coefficients of resistance as quenched, and they also have interesting elastic properties. This combination makes them attractive for various specialized applications. The manganese-copper alloys are not very corrosion resistant.

Of the manganese-copper alloys, the 80 manganese-20% copper alloy is in commercial production. This alloy has an unusual combination of elastic properties; as shown in the table, it combines a low modulus of rigidity and an extremely high Poisson's ratio. In addition, when properly heat treated, it has high damping capacity; internal friction Q, is reported to be 1750, compared with 5 for beryllium copper. The maximum damping capacity occurs at a stress of 10,000 psi and, in practical use, it is necessary that the vibratory stress be superimposed upon an initial stress.

The 80-20 alloy is available in hot or cold rolled bars for forgings, in heat treated parts and in sheet. The alloy can be hot worked at 1600 to 1650 F or worked in the range from room temperature to 500 F. Working between 500 to 1500 F must be avoided because



Metals & Controls Corp.

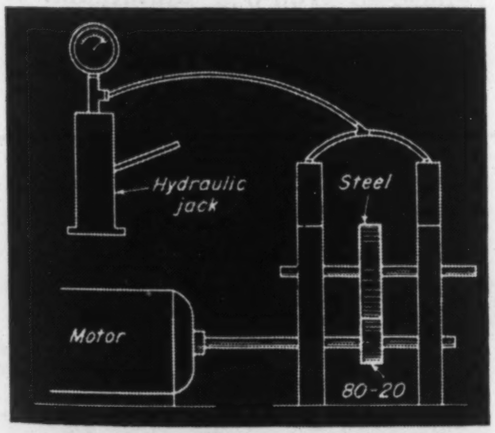
W. M. Chace Co.

Typical parts *made from bimetal combinations of 72-18-10 alloy are shown here.*

the alloy is brittle in this range.

Among applications for this alloy are cams for textile machinery. A test against a hardened steel follower-roll showed that the alloy had a much higher safe load factor than some other materials —3000 lb per sq in. of face on the cam follower, compared with 750 for cast iron and 600 for nylon. Because of its high damping capacity, the 80-20 alloy also performs at a low noise level.

The unusual combination of elastic constants permits a high degree of conformance between the 80-20 alloy and a steel surface when the two are pressed together. This effect has resulted in the development of a friction transmission in which a film of oil is maintained between the surfaces at high pressure and, in effect, acts as a solid. The simplest transmission of this type uses a set of rolls: one steel, the other manganese alloy. In this system,



Chicago Development Corp.

Friction transmission *based on the unusual elastic properties of the 80-20 manganese copper alloy can transmit about ¼ hp with a roll width of ½ in.*

The Properties of Manganese

Manganese exists in three, or possibly four, structures depending on the temperature. These structures are called alpha, beta, gamma and delta; transformation from one to the other occurs as follows:

Alpha to beta—1340 F
Beta to gamma—2010 F
Gamma to delta—2080 F

These changes are important to the engineer only because of the properties of the various phases. Alpha, which is the phase stable at ordinary temperatures, is brittle and cannot be fabricated. Beta, stable at moderately elevated temperatures, is also brittle. The high temperature phase, gamma, is sufficiently ductile to be cold worked. Unfortunately, the gamma phase cannot be retained in pure manganese at room temperature. However, this phase can be retained in certain alloys and these alloys are the basis of some engineering applications of manganese.

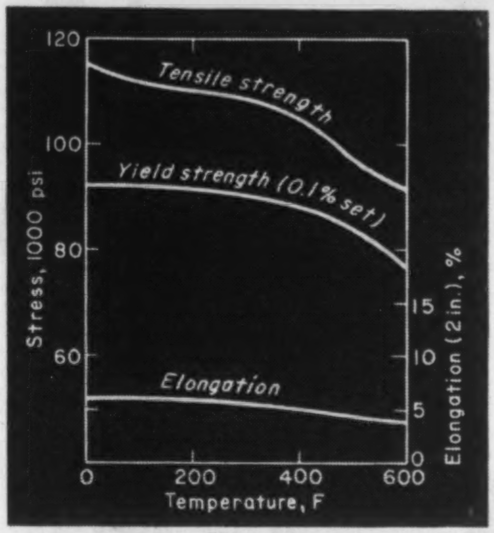
Manganese has about the same density as iron, its coefficient of thermal expansion is in the same range as those of aluminum and magnesium, and it has a relatively low melting point. Probably its outstanding physical property is its high electrical resistivity — roughly 100 times that of copper and three times that of austenitic stainless steel (18-8).

Manganese oxidizes slowly in air and decomposes cold water slowly and warm water rapidly. It dissolves readily in dilute mineral acids but is not attacked by boiling concentrated solutions of potassium or sodium hydroxide. It reacts with sulfur, and forms a nitride when heated with ammonia.

SOME PROPERTIES OF ELECTROLYTIC MANGANESE[a]

Density, lb/cu in	0.268
Melting Point, F	2273
Coef of Ther Exp (68 F), per °F	12.2×10^{-6}
Specific Heat (68 F), Btu/lb/°F	0.114
Elec Res (68 F), microhm-cm	185

[a] Properties of the modification stable at room temperature.



Chicago Development Corp.

***Effect of temperature** on mechanical properties of 72-18-10.*

about ¼ hp can be transmitted with a roll width of ½ in. Conical rolls can be used to obtain variable speed transmission.

The 80-20 alloy is also used in gears to reduce vibration and noise, and as a vibration absorbing axle in instruments such as clocks having Geneva movements.

A 95 manganese-5% copper alloy is also in production on a limited scale. This alloy is ductile and has been rolled to 0.003-in. sheet without difficulty. Information on properties and applications of this alloy is not available.

2. Manganese-copper-nickel

The manganese-copper alloys containing 60 to 80% manganese are not stable above 575 F. Substitution of nickel for part of the copper increases thermal stability, and alloys of this type containing 10% nickel are not affected by heat treatment. Addition of nickel does not markedly affect the high electrical resistivity and low temperature coefficient of electrical resistance that are characteristic of the manganese-copper alloys, but does improve corrosion resistance.

The most useful attribute of the modified alloys, however, is their high coefficient of thermal expansion. The highest coefficient of the group occurs in an alloy of 72 manganese-18 copper-10% nickel, and this alloy is commercially the most important of the manganese-base alloys. As shown in the table, this alloy has a coefficient of expansion of 14.2 x 10^{-6} per °F, the highest coefficient of any alloy having a comparable yield strength

Although the manganese-copper-nickel alloys are more resistant to atmospheric attack than the manganese-copper alloys, some are sensitive to intergranular attack by salt solutions, including perspiration, and require surface protection (which may be simply lacquer). However, the 72-18-10 alloy is immune to attack.

The 72-18-10 alloy also has a thermal conductivity of 5 Btu/hr/sq ft/°F/ft. This value is in contrast to 226 for copper, 67 for yellow brass, 27 for low carbon steel and 9 for stainless steel (18-8).

The mechanical properties of 72-18-10 are also attractive, combining relatively high strength with good ductility. As shown in an accompanying graph, these properties are not greatly reduced by heating to 600 F.

The alloy is commercially available in sheet, strip, hot rolled bars, extruded tubing and special shapes. It can be cold worked readily and hot worked at 1600-1650 F. It has machinability comparable with that of monel.

This high manganese alloy can be joined to itself or to steel by resistance welding, atomic hydrogen welding, oxyacetylene welding or by silver alloy brazing. After welding, no thermal or chemical treatments are required to restore corrosion resistance.

Extensive use is made of 72-18-10 as a component of thermostatic bimetallic elements. With its high coefficient of expansion, it provides maximum energy per degree of temperature change.

The relative movement of bimetal combinations is indicated by the ASTM flexivity test. The procedure (given in ASTM B 106-51T) involves changing the temperature of a strip of bimetal and determining the dimensional changes, or flexivity, by calculation. Brass-Invar, probably the most widely used bimetal combination, has a flexivity value of 1.52 x 10^{-5} over the range 50 to 200 F. Over the same range, a bimetallic strip composed of 50% of the 72-18-10 alloy and 50% Invar has a flexivity value of 2.13 x 10^{-5}, highest of the bimetals in commercial use. This bimetal combination also has an electrical resistivity equivalent to that of the most widely used resistance alloy, 80 nickel-20% chromium.

Since its damping capacity is about 25 times that of hardened steel at low stresses, this alloy is also used to eliminate sustained resonance of metallic members resulting from intermittent shock. It has been employed for damping vibrations in applications for which rubber is unsuitable.

Other applications include low temperature resistors, auxiliary rheostats for circuit breakers, components of electrical appliances, and drive shafts that require low heat transmission.

3. Manganese-iron-aluminum

Binary manganese-iron alloys containing 50% of each element have relatively low coefficients of expansion, but replacement of part of the iron by aluminum, nickel or cobalt improves the properties. Of the three addition elements, aluminum yields the best properties and a commercial alloy has been developed.

This alloy contains 50 manganese-45 iron-5% aluminum. It has a coefficient of expansion close to those of some ceramic materials and a relatively high electrical resistance. It has been used as the terminals on enameled resistors, but applications are limited because the coefficient of expansion is constant only up t about 400 F.

Acknowledgment

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Foote Mineral Co.
General Plate Div., Metals & Controls Corp.

Here's the

WHO: Any person, persons or organization in the product manufacturing industries, or consultants serving these industries, may submit an entry or entries. No one employed by a materials producer or supplier is eligible.

WHAT: Entries may be either a new product or a redesigned product that demonstrates sound, imaginative and progressive use of engineering materials. The design must have been completed or the product put into production during the calendar year of 1957. Engineering materials are defined as metals, nonmetallics, finishes and coatings, and materials forms (such as castings, forgings, moldings, etc.). The product may be a complete assembly, a subassembly, a single part or a component. See back of this page for details on the information that must be submitted with each entry.

WHEN: Entries must be mailed no later than January 15, 1958.
Mail all entries to Awards Editor,
MATERIALS IN DESIGN ENGINEERING
430 Park Avenue, New York 22, N. Y.

WHERE: Awards will be made during the week of the Design Engineering Show, April 14-17, 1958, in Chicago. The exact time and place will be announced in an early issue of MATERIALS IN DESIGN ENGINEERING.

WHY: Purpose of the Awards Program is to encourage and reward sound, imaginative and progressive use of engineering materials in the design and redesign of industrial and consumer products. Sixteen cash awards will be given—

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ENTRY FORM NEXT PAGE →

ENTRY FORM

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1957-58 AWARDS COMPETITION

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The following information must be provided with each entry in order to allow the judges to make competent decisions.

a. A detailed description of the product including photographs or drawings. If the entry is a redesign, provide before and after illustrations if possible.

b. A description of requirements in service and/or fabrication that must be met by the product and the material.

c. A description of the previously used materials (if entry is a redesign).

d. A description of the material or materials selected for the product entry.

e. An explanation of why the material or materials were selected for the product. Describe the advantages or benefits gained through the choice. Back them up with evidence — facts, data, charts, tables on performance, quality or cost.

In general, entries should show that the materials selected for the product —

Resulted in improved performance and/or lower costs

or

Best met the design and service requirements.

Here are a few specific ways in which a product can benefit from intelligent materials selection:

- Long service life
- Lower basic materials cost
- Less material required
- Improved appearance
- Permitted a new design
- Reduced production costs
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- Reduced scrap
- Reduced or eliminated maintenance
- Permitted lower cost design
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Remember! The more detailed and documented your entry is, the more consideration it will receive from the judges.

2. Entries or portions of entries will not be returned unless requested. Entries should not include valuable papers or other material which must be returned, because there is always some danger of loss or mutilation. Whenever possible, photostats, photographs or other copies of such materials should be used instead.

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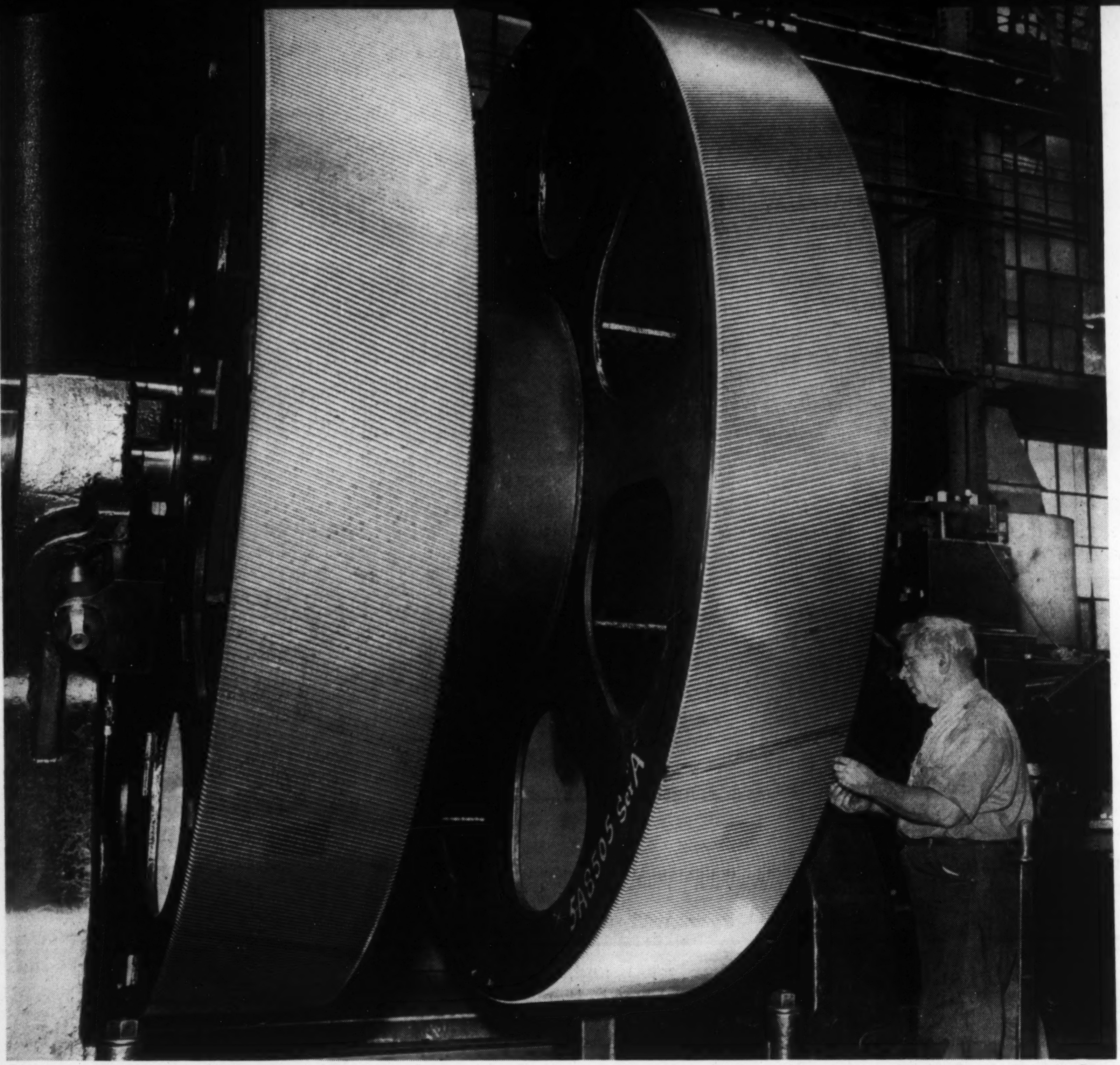


Westinghouse Electric Corp.

Huge marine reduction gear *typifies problem of selecting right material for specific end application. This gear is built up of plain carbon steel hub and webs to which are welded gear rims of carbon or molybdenum-vanadium steel.*

Materials for Gears

by **Norman E. Woldman,** *Consulting Engineer*

Materials
in Design Engineering
Manual No. 143
November 1957

The satisfactory performance of a gear depends to a large degree upon the materials of which it is made. A large number of gear materials are available to the designer for specific end applications. This article encompasses:

- *Selection factors you should consider*
- *Data on metals and nonmetallics for gears*

Selection Factors

The primary function of a gear is to transmit power and/or motion. To perform its function effectively a gear must meet several essential requirements, principal of which are: 1) adequate load carrying capacity, 2) resistance to wear and pitting, and 3) resistance to bending fatigue.

In selecting a gear material it is necessary to have a thorough knowledge of the loads to which a gear will be subjected, as well as a proper appreciation of the limits imposed by manufacturing methods. Chemical composition is not the only criterion used in selecting and specifying a gear material. Cost, method of manufacture, character and degree of mechanical working, and mill heat treatment are typical of the factors that must also be considered. The proper material to use is one that meets design requirements, as well as the machining and heat treating requirements of the production department and the cost and availability requirements of the purchasing department.

Strength

The strength of a gear depends on a number of factors; the most important are tooth form and material. In selecting a suitable material it is first necessary to determine operating loads and stresses. The load on each tooth and, in turn, the total load carrying capacity of a gear, is determined by the number of teeth that are in contact. Also, because of impact loading, the stress on a tooth is generally considered to be much higher when the tooth is operating at zero or near zero speeds than when it is operating at high speeds.

Durability

The durability of a gear is related to material toughness and hardness. Gears of relatively soft steels have self-correcting properties which make them useful if misalignment is liable to be present. Gears that are heat treated after cutting are subject to distortion and may produce highly concentrated and localized loading. These gears are often subject to fatigue bending and tooth breakage at loads that would not have any effect on gears heat treated before cutting.

Toughness

In general, the impact resistance of a gear decreases as its hardness and surface durability increase. Toughness and resilience are a good measure of resistance to overloads, shocks and impact, and these properties determine if a gear member can absorb the energy of a moving body. In other words, toughness is a measure of ultimate energy strength and determines the reserve strength available for resisting excessive energy loads.

Wear resistance

The wear resistance of a gear is a function of its hardness, strength and plasticity. A rough formula can be derived which states that the wear resistance of a material is equal to the product of its hardness and toughness. To wear well a metal must resist the displacement of its particles (hardness) and, if the particles are displaced, it must resist the removal of its particles (toughness). Generally, if two metals have the same tensile strength, the metal with the highest ductility will also have the greatest wear resistance. Also, assuming a given ductility, a material's wear resistance can be increased by increasing its tensile strength and the fineness of its crystal structure.

Finish and fatigue

The resistance of a gear to bending fatigue is greatly influenced by surface finish. In all cases surfaces should be smooth and free from defects. No matter how perfectly they are finished, the surfaces of repeatedly stressed gear teeth are much more vulnerable to failure than deeper layers. Vulnerability to fatigue increases with surface roughness, particularly if the roughness consists of notches that are oriented at right angles to the principal stress.

However, highly polished surfaces and fillets may lead to a false sense of security if, as the result of machining or straightening operations, internal stresses of the wrong kind are produced. Certain grinding operations can produce high surface tension stresses and thus promote fatigue failure.

Since fatigue failure is largely due to tensile stresses, these stresses should be reduced or removed wherever possible or, better still, converted to compressive stresses by suitable treatment. The most plausible explanation of the effectiveness of surface compression stresses is that when a load is applied the tension stress it produces is decreased by the amount of compression prestress. Thus, since fatigue failure starts only from tension stresses, the fatigue durability of the surface layer is increased.

The superior fatigue strength of surface hardened steels is due to compressive stresses. These stresses are helpful in resisting bending and torsion. Surface compressive stresses can be produced by peening, nitriding, carburizing, flame or induction hardening, or drastic quenching. Surface compressive stresses of over 160,000 psi have been reported for nitrided steel, 90,000 psi for carburized steel, and 30,000 to 40,000 psi for induction hardened steel.

Since gear failures usually occur in regions of localized stress concentration, particular attention must be given to the problem of stress raisers. Some stress raisers are the results of poor design and are produced by notches, sharp corners, abrupt section changes, inadequate fillets, grooves, re-entrant angles, keyways, oil holes and screw threads. Other stress raisers are the result of poor fabrication and are produced by inferior machining, tool marks, scratches, quenching and grinding cracks, and sharp inspection stamps on highly stressed surfaces.

Gear Materials—
A Quick Summary of Their Properties

Carburizing Steels	Combine maximum surface hardness and wear resistance with interior toughness and shock resistance. Best suited for heavy duty service. Offer high resistance to wear, pitting and fatigue. Low carbon content provides maximum ductility; higher carbon content provides maximum core strength. Core and case properties depend largely on type of heat treatment.
Nitriding Steels	Case properties generally same as carburizing steels. Useful for large gears with thin sections. Nitrided steels retain hardness at temperatures up to 800 F.
Through Hardening Steels	Possess greater core strength and provide quieter operation than carburized steels. Less expensive than carburizing steels because of simpler heat treatment required. Not as ductile or as resistant to surface compression stresses as case hardened steels. Relatively shallow hardening types suitable for gears requiring only moderate strength and impact resistance. Medium to deep hardening materials suitable for gears requiring medium to high wear resistance and high load carrying capacity.
Special Gear Steels	
Leaded Steels	Reduce machining time and costs. Permit faster metal removal through use of deeper cuts and faster cutting speeds.
High Manganese Steels	High resistance to heat, wear and bending stresses. Surfaces become work hardened and polished after use.
Boron Steels	Used for highly stressed gears.
Stainless Steels	High corrosion resistance combined with excellent mechanical properties.
Ultra High Strength Steels	Combine maximum ductility with high tensile strengths (230,000 psi and over).
Pre-heat Treated Bar Steels	Used for gears that cannot be heat treated after machining. Use where distortion cannot be tolerated, tolerances are small, or where grinding to close tolerances is impractical.
Gray Cast Iron	Combine low cost with good damping capacity and good wear resistance when properly lubricated. Relatively weak compared with rolled, forged or cast steel. Quality depends to large degree on foundry practice.
Nodular or Ductile Iron	Good casting and machining properties. Wear resistant. Higher strength than gray cast iron. Respond well to heat treatment and make dependable power transmission elements
Bronzes	
Tin Bronze	Good hardness, strength and resilience. Recommended for general purpose worm wheels.
Silicon Bronze	Usually used for worm wheels that mate with case hardened worms. Recommended for medium loads and medium to high speeds.
Phosphor Bronze	Used for worm wheels that mate with worms of high hardness and fine accuracy. Generally recommended for medium loads and medium to high speeds. Some grades can be used under heavy pressures and severe working conditions.
Leaded Bronze	Recommended for worm gears to mate with soft steels under low loads and low to medium speeds.
Manganese Bronze	High manganese bronze is highly wear resistant. Recommended for high loads and speeds.
Aluminum Bronze	Combines high strength and hardness with good resistance to wear and fatigue. Particularly suited for severe service where long life is required.
Nickel Bronze	Good yield strength, toughness and wear resistance.
Metal Powders	Low cost when produced in large quantities. Widely used for low loads and comparatively low speeds. Properties can be considerably improved by carburizing and impregnation.
Nonmetallic Materials	
Molded Plastics	Quiet operation, good resiliency, vibration and damping properties, combined with low cost in large quantities.
Reinforced Laminates	Properties generally same as molded materials.
Rawhide	Quiet operation combined with high shock resistance, comformability and resiliency

Ferrous Metals

Steel is the most widely used ferrous material for gears since it can be manufactured and processed to a great many different specifications, each of which has a definite use. In general, there are two types of gear steels: surface hardening and through hardening. The surface hardened steels are hardened to a relatively thin case depth and include carburizing and nitriding steels in low carbon, plain or alloy types. Through hardening steels may be comparatively shallow hardening or deep hardening, depending on their chemical composition and method of hardening.

Carburizing steels

General properties — Carburizing or nitriding grades of steel are usually specified where maximum wear resistance is required for bearing surfaces. Carburized, case hardened gears are best suited for heavy duty service, e.g., transmission gears, and offer high resistance to wear, pitting and fatigue. Surfaces must be sufficiently hard to resist wear and of sufficient depth to prevent crushing. A rough rule for case depth is that it shall not exceed one-sixth of the base thickness of the tooth.

A case hardened gear provides maximum surface hardness and wear resistance, and at the same time provides interior toughness to resist shock. In general, case hardened gears can withstand higher loads than through hardened gears, although the latter are quieter and are less expensive because of the simpler heat treatment required.

Selection factors—A number of factors must be considered when selecting a case hardened gear:

1. High tooth pressures will crack a thin case.
2. Too soft a core will not provide proper backing for a hard case.
3. Compressive stresses in the case improve fatigue durability, and a high case hardness increases wear resistance.

4. If the ratio of case depth to core thickness is too small, excessive stresses in subsurface layers can produce poor fatigue life.

5. Residual tensile stresses are highest with low core hardness and increase with increasing case depth. These stresses can be relieved by tempering.

Grain size variations have an important effect on core properties. These variations are influenced by the type of steel and the method of heat treatment used subsequent to carburizing. Section thickness also influences core properties.

A tough tooth core may not be required in applications where a gear will not be subjected to impact loading. In these applications core properties are relatively unimportant, provided the core is sufficiently hard to support the case. Considering the case alone, it is important that the surface resist wear and fatigue bending, since bending stresses vary from a maximum at the surface to zero near the tooth center.

Effects of composition—The carbon content of carburized gears is usually within the range of 0.10 to 0.25%. (A carbon content of 0.35% has also been occasionally used.) A low carbon content is usually used to obtain maximum ductility, and a high carbon content is used to obtain maximum core strength. The recent trend is toward high carbon gears with comparatively shallow cases produced by gas carburizing or activated carburizing baths.

In all typical case hardening carbon and alloy steels the desired carbon content is obtained by specifying the proper AISI (or SAE) designation. The last two digits of the steel designation indicate the mean carbon content. The 1100 series carbon steels are the free-cutting grades. Some representative AISI carburizing steels used for gears are: 1015, 1020, 1022, 1025, 1117, 1118, 2317, 2515 and 3120. Also, 3310, 4020, 4118, 4320, 4620, 4820, 5120, 6120, 8620, 8720 and 9310. Many other standard and special carburizing steels of low and high carbon and alloy content are also available.

The nickel carburizing steels are used chiefly where exceptional core toughness combined with the highest degree of wear resistance

TABLE 1—PROPERTIES OF TYPICAL CARBURIZED GEAR MATERIALS*

Steel ↓	Carbon Content	Heat Treatment (see key)	Brinell Hardness	Tensile Strength, psi	Yield Point, psi	Elongation in 2 in., %	Reduction of Area, %	Izod Impact Strength, ft-lb
1-In. Rods								
C1015	0.15	A1	149	73,000	46,000	32	71	91
C1020	0.20	A1	156	75,000	48,000	31	71	93
C1022	0.22	A1	163	82,000	47,000	27	66	81
C1117	0.17	A2	192	96,500	59,500	23	53	33
C1118	0.18	A2	229	113,000	76,500	17	45	16
½-In. Rods								
2317	0.17	B11	195	95,000	60,000	35	65	85
		B12	210	100,000	65,000	30	60	70
2515	0.17	B13	277	130,000	90,000	24	60	65
		B14	352	170,000	135,000	14	50	40
3115	0.17	B15	212	100,000	70,000	25	55	55
3310	0.10	B1	375	181,500	149,000	15	57	40
		B2	363	180,000	145,500	14	57	55
		B3	352	177,000	143,500	15	58	47
		C1	375	181,000	153,000	15	58	40
		C2	363	180,000	149,500	14	58	57
		C3	341	175,500	146,500	15	59	50
4320	0.20	B1	429	217,000	159,500	13	50	33
		B2	429	218,000	178,000	14	48	28
		B4	302	152,000	97,000	20	49	49
		C1	415	215,000	159,000	13	49	26

KEY TO HEAT TREATMENT

A—Single quench and temper

1—Carburized at 1675 F for 8 hr, pot cooled, reheated to 1425 F, water quenched, tempered at 350 F.
2—Carburized at 1700 F for 8 hr, pot cooled, reheated to 1450 F, water quenched, tempered at 350 F.

B—Recommended practice for maximum case hardness

1—Direct quench from pot: quenched in oil, tempered at 300 F.
2—Single quench and temper for good case and core properties: pot cooled, reheated to 1500 F, quenched in oil, tempered at 300 F.
3—Double quench and temper for maximum grain refinement of case and core: pot cooled, reheated to 1500 F, quenched in oil, reheated to 1450 F, quenched in oil, tempered at 300 F.
4—Same as B3 except final quench from *1425 F*.
5—Same as B3 except final quench from *1475 F*.
6—Same as B2 except final quench from *1475 F*.
7—Same as B2 except final quench from *1550 F*.
8—Same as B3 except pot cooled, reheated to *1550 F*, quenched in oil, reheated to *1475 F*, quenched in oil, tempered at 300 F.
9—Same as B2 except reheated to *1450 F*.
10—Same as B3 except pot cooled, reheated to *1475 F*, quenched in oil, reheated to *1425 F*, quenched in oil, tempered at 300 F.
11—Same as B3 except reheated to *1525 F*, quenched in oil, reheated to *1375 F*, quenched in oil, tempered at 300 F.

and greatest surface compressive strength is required. These steels are the nickel steels (2000 series), nickel-chromium steels (3000 series), nickel-molybdenum steels (4600 and 4800 series), and nickel — chromium — molybdenum steels (4300, 8600, 8700 and 9300 series). The carbon-molybdenum steels (4000 series) are used where exceptional toughness and good resistance to temper brittleness are required.

Another advantage of the more highly alloyed steels is the ability of heavy sections to harden more completely. This greater hardenability promotes better core strength properties than can be achieved with shallow hardening steels quenched in the same size section.

Effects of heat treatment—Table 1 lists the properties that can be expected of typical case hardened carbon and alloy steels. As shown, three methods of quenching and tempering can be used to obtain varying ranges of case and core properties. Method A consists of a single quench and provides a good compromise of case and core properties. Method B is recommended for maximum case hardness and Method C is recommended for maximum core toughness.

In the past, double quenching was recognized as the best method for obtaining optimum case and core properties. However, to avoid the danger of distortion inherent in double quenching treatments, most carburized gears are currently given a single quenching. The development of a single quench treatment has been made possible by steels with controlled grain size that maintain a fine grained structure after heat treatment.

Nitriding steels

Nitriding steels can be used in many gear applications where a hard, wear resistant case, good fatigue strength, low notch sensitivity and some degree of corrosion resistance are desired. Since the hardness of nitrided steel surfaces does not change at temperatures as high as 800 F, these steels are quite useful in applications where hardness must be maintained at temperatures that would destroy a carburized surface. In addition, nitriding

TABLE 1—PROPERTIES OF TYPICAL CARBURIZED GEAR MATERIALS[a]—continued

Steel ↓	Carbon Content	Heat Treatment (see key)	Brinell Hardness	Tensile Strength, psi	Yield Point, psi	Elongation in 2 in., %	Reduction of Area, %	Izod Impact Strength, ft-lb
½-In. Rods—continued								
		C2	415	212,000	173,000	13	51	29
		C4	293	146,000	94,500	22	56	49
4620	0.17	B1	311	148,000	116,500	17	56	47
		B2	277	119,000	83,500	20	59	52
		B5	248	122,000	77,000	22	56	64
		C1	302	147,500	116,000	17	58	43
		C2	248	115,500	81,000	21	64	69
		C5	235	115,000	77,000	23	62	78
4820	0.21	B1	415	205,000	165,500	13	53	33
		B6	415	207,500	167,000	14	52	44
		B3	415	204,500	165,500	14	52	31
		C1	401	200,500	170,000	13	53	30
		C6	415	205,000	184,500	13	53	47
		C3	401	196,500	171,500	13	53	29
8620	0.23	B1	388	192,000	150,000	13	50	28
		B7	388	188,500	150,000	12	52	26
		B8	269	133,000	83,000	20	57	56
		C1	352	181,000	134,000	13	51	34
		C7	341	168,000	121,000	14	53	30
		C8	262	130,000	77,000	23	52	66
9310	0.11	B1	375	179,500	144,000	15	59	57
		B9	363	173,000	135,000	16	60	61
		B10	363	174,500	139,000	15	62	54
		C1	363	178,000	146,500	15	60	46
		C9	341	168,000	137,500	16	60	39
		C10	352	169,500	138,000	15	62	63

12—Same as B11 except final quench in water.

13—Same as B3 except reheated to 1500 F, quenched in oil, reheated to *1350 F*, quenched in oil, tempered at 300 F.

14—Same as B3 except reheated to *1525 F*, quenched in oil, reheated to *1400 F*, quenched in oil, tempered at 300 F.

15—Same as B3 except reheated to *1550 F*, quenched in oil, reheated to *1400 F*, quenched in oil, tempered at 300 F.

C—Recommended practice for maximum core toughness

1—Direct quench from pot: quenched in oil, tempered at 450 F.

2—Single quench and temper for good case and core properties. pot cooled, reheated to 1500 F, quenched in oil, tempered at 450 F.

3—Double quench and temper for maximum grain refinement of case and core: pot cooled, reheated to 1500 F. quenched in oil, reheated to 1450 F, quenched in oil, tempered at 450 F.

4—Same as C3 except final quench from *1425 F*.

5—Same as C3 except final quench from *1475 F*.

6—Same as C2 except reheated to *1475 F*.

7—Same as C2 except reheated to *1550 F*.

8—Same as C3 except pot cooled, reheated to *1550 F*, quenched in oil, reheated to *1475 F*, quenched in oil, tempered at 450 F.

9—Same as C2 except reheated to *1450 F*.

10—Same as C3 except pot cooled, reheated to *1475 F*, quenched in oil, reheated to *1425 F*, quenched in oil, tempered at 450 F.

steels make it possible to surface harden the teeth of large gears having thin sections that might be impractical to carburize and quench.

Nitrided gears are relatively free from wear up to the load at which surface failure occurs, but at this load they become badly crushed and pitted. Thus, nitrided gears are generally not suitable for applications where overloads are liable to be encountered.

Hardness of the case is a function of the amount and nature of the nitride forming elements present, carbon content and nitriding temperature. Carbon tends to form carbides with the nitride forming elements and removes them from solid solution so that they are not available for hardening during nitriding. Nitriding steels containing no aluminum have lower surface hardness, but their case is considerably tougher and they can be peened without causing any spalling.

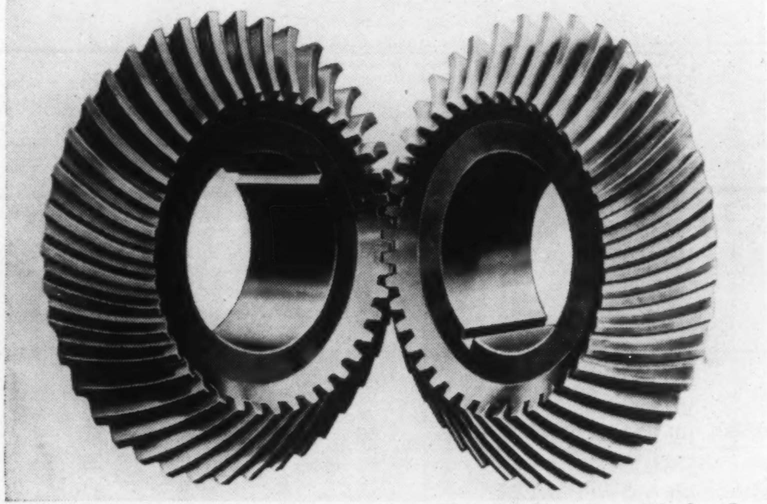
Several grades of Nitralloy steels are available for surface hardening by the nitriding process. These include: Nitralloy 115, 125, 135, 135 Modified, 225, 230 and N.

Nitralloy N, a nickel nitriding steel, is a precipitation hardening alloy which attains a core strength and hardness after nitriding that are considerably in excess of its original properties. Both Nitralloy N and 135 Modified are outstanding for heavy duty gears that are highly stressed (see Table 2 for typical core properties). Little change in tensile strength of nitriding steels occurs if the tempering temperature used for treating the core is at or above the nitriding temperature. However, because of the increased hardness of the case, the elongation, ductility and impact strength of both alloys are considerably reduced after tempering, though not to the same extent; Nitralloy N develops a tougher and softer surface and a stronger core than Nitralloy 135 Modified.

Any of the AISI steels that contain nitride forming elements, such as chromium, vanadium or molybdenum, can also be nitrided. The steels most commonly nitrided are 4140, 4340, 6140 and 8740. In some applications the 0.50% carbon grades are also used.

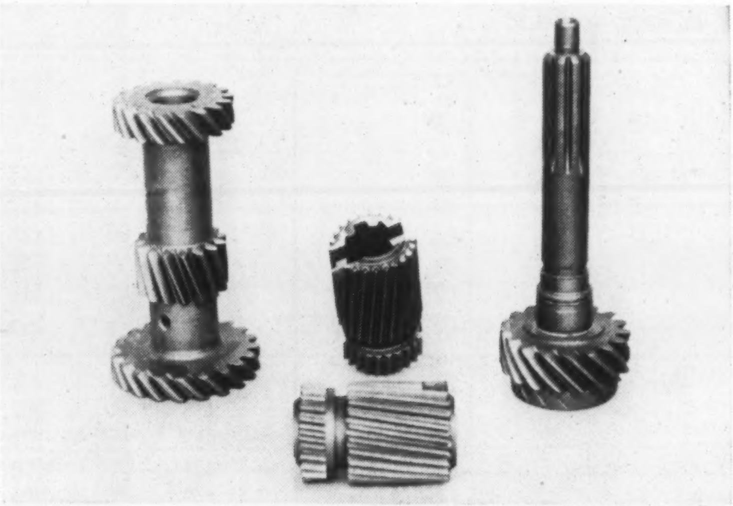
In some applications it may be desirable to nitride the gear teeth only and leave the rest of the gear

Alloy steel gears: a wide range of properties



Philadelphia Gear Works, Inc.

SAE 4320 *steel carburized and hardened to 75 to 85 Shore is used for this pair of spiral bevel miter gears.*

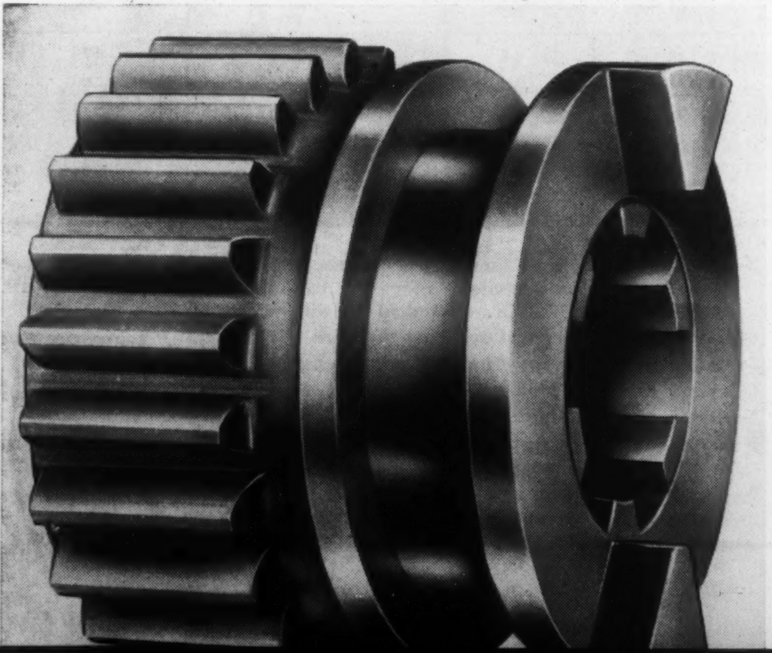


Ajax Electric Co., Inc.

SAE 1340 *automobile transmission gears are case hardened to a depth of 5 mils by liquid cyaniding.*

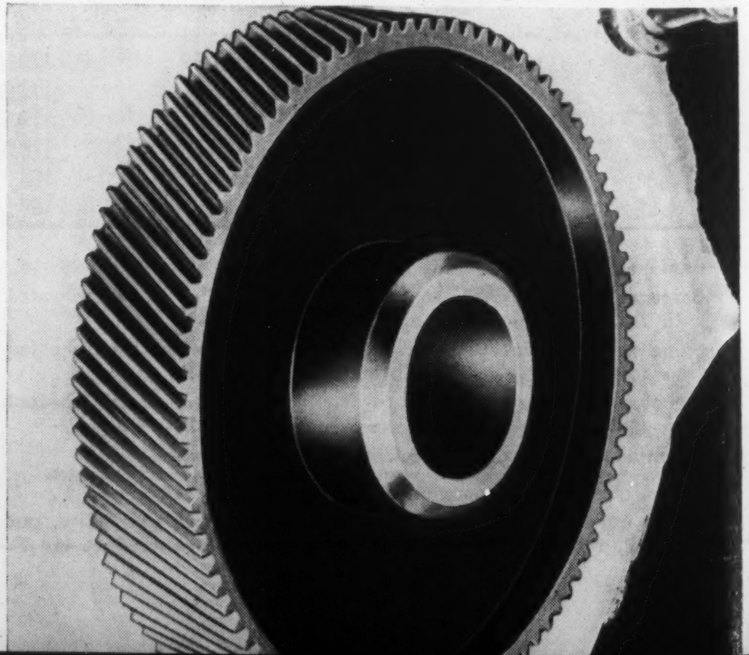
SAE 4140 *clutch spur gear is induction hardened to 520 Brinell.*

Philadelphia Gear Works, Inc.



SAE 4640 *cast steel helical gear is flame hardened and quenched to hardness of 65 to 75 Shore.*

Philadelphia Gear Works, Inc.



soft. Such selective hardening can be done with a stop-off coating such as tin plate. The entire gear is tin plated to 0.3 to 0.5 mil and the tin plate removed from the teeth before nitriding.

Through hardening steels

By virtue of their higher carbon content, through hardening steel gears possess greater core strength than carburized gears. They are not, however, as ductile or as resistant to surface compressive stresses and wear as case hardened gears. Hardness of gear surfaces may vary all the way from 300 to 575 Brinell.

Typical of the relatively shallow hardening, carbon steel gear materials are types 1035, 1040, 1045, 1050, 1137, 1141, 1144 and 1340. These steels are water hardening, but not deep hardening, types and are suitable for gears requiring only a moderate degree of strength and impact resistance.

In general, the more highly alloyed through hardening steels harden more completely when quenched in heavy sections. This greater hardenability provides greater strength than can be attained with shallow hardening steels quenched in the same size section.

Typical of the low alloy, medium to deep hardening gear materials are (in order of increasing hardenability): 4042, 5140, 8640, 3140, 4140, 8740, 6145, 9840 and 4340. These steels, as well as many other alloy steels with the proper hardenability characteristics and a carbon content of 0.35 to 0.50%, are suitable for gears requiring medium to high wear resistance and high load carrying capacity.

The core properties of representative through hardening carbon and alloy gear materials are listed in Table 3. Other standard and special through hardening steels are available. In selecting a through hardening steel it should be borne in mind that a higher carbon and alloy content is accompanied by greater strength and hardness (but lower ductility) of the surface and core.

Fully hardened and tempered

TABLE 2—PROPERTIES OF TYPICAL NITRIDING STEELS[a]

Alloy ➡	Nitralloy 135 Modified		Nitralloy N	
	Before Nitriding	After Nitriding	Before Nitriding	After Nitriding
Tensile Strength, psi	138,000	138,000	132,000	190,000
Yield Point, psi	120,000	110,000	114,000	180,000
Elongation in 2 in., %	26	4	22	6–15
Reduction of Area, %	60	17	59	43
Brinell Hardness	320	310	277	415
Charpy Impact Strength, ft-lb	44	21	—	—

[a] Nitrided for 90 hr at 900 F, quenched in oil and tempered at 1200 F.

TABLE 3—CORE PROPERTIES OF THROUGH HARDENED CARBON AND ALLOY STEEL GEAR MATERIALS

Type of Steel ⬇	Tensile Strength, psi	Yield Point, psi	Elongation in 2 in., %	Reduction of Area, %	Izod Impact Strength, ft-lb	Brinell Hardness
WATER QUENCHED CARBON STEELS (1-IN. BARS)						
C1030	122,000	92,000	16	47	9	475
C1040	130,000	95,000	17	50	10	475
C1050	160,000	116,000	12	34	9	475
C1137	216,000	168,000	4	17	7	415
C1144	290,000	188,000	5	11	2	555
OIL QUENCHED CARBON STEELS (1-IN. BARS)						
C1137	156,000	136,000	6	22	10	352
C1144	127,000	92,000	16	36	7	277
WATER QUENCHED ALLOY STEELS (½-IN. BARS)						
2330	250,000	205,000	12	50	30	460
4130	232,000	196,000	12	43	32	460
8630	228,000	210,000	11	52	26	460
OIL QUENCHED ALLOY STEELS (½-IN. BARS)						
1340	235,000	205,000	10	42	7	475
3140	242,000	218,000	12	50	22	475
4140	240,000	220,000	12	47	9	475
4150	237,000	220,000	10	39	12	475
4340	248,000	216,000	13	49	13	475
4640	243,000	227,000	12	47	13	475
5150	245,000	223,000	10	39	7	475
6150	235,000	216,000	10	40	11	475
8740	240,000	220,000	12	47	15	475
8750	237,000	218,000	12	42	14	475
9440	236,000	213,000	12	50	11	475
9255	233,000	215,000	8	23	6	475
OIL QUENCHED ALLOY STEELS (1-IN. BARS)						
2345	240,000	220,000	13	40	9	475
3145	245,000	218,000	8	28	5	475
3250	243,000	214,000	9	37	8	475
4340	242,000	222,000	12	45	14	475
4640	238,000	218,000	11	43	14	475
8645	235,000	210,000	11	40	12	475

Properties of special gear steels

TABLE 4—PROPERTIES OF MARTENSITIC STAINLESS STEEL GEAR MATERIALS

AISI Type ➡	403	410	414	416	420	431	440A
Tensile Strength, psi	180,000	180,000	190,000	180,000	230,000	195,000	260,000
Yield Strength, psi	140,000	140,000	145,000	140,000	195,000	150,000	240,000
Elongation in 2 in., %	15	15	15	13	8	15	5
Izod Impact Strength, ft-lb	35	35	45	20	10	45	4
Brinell Hardness	375	375	400	375	500	400	510

TABLE 5—PROPERTIES OF TYPICAL ULTRA HIGH STRENGTH STEELS[a]

Steel ➡	Hy-Tuf	Super Hy-Tuf	Tricent
Tensile Strength, psi	235,000	294,000	297,000
Yield Strength, psi	191,000	241,000	242,000
Elongation in 2 in., %	14	10	8
Reduction of Area, %	50	35	23
Rockwell Hardness	C47	C54	—
Impact Strength, ft-lb	33 (Izod)	—	18 (Charpy)

[a] 1-in. dia; oil quenched and tempered at 500 F.

TABLE 6—PROPERTIES OF TYPICAL PREHEAT TREATED BAR STEELS

Steel ➡	Stressproof	Fatigue-proof	Ryax	Rycrome	Elastuf A-2
Tensile Strength, psi	135,000	145,000	114,000	150,000	135,000
Yield Strength, psi	107,000	135,000	75,000	128,000	125,000
Elongation in 2 in., %	13	7	23	18	20
Brinell Hardness	285	300	225	311	285

medium carbon alloy steels possess an excellent combination of strength and toughness at room temperature and at lower temperatures. However, toughness can be substantially decreased by temper brittleness, a form of embrittlement developed in some alloy steels by slow cooling through the temperature range of 850 to 1000 F, or by holding or tempering in this range. Because of their good hardenability and immunity to temper brittleness, molybdenum steels have been widely used for gears requiring good toughness at room and low temperatures.

Special gear steels

Leaded steels—The principal advantage of leaded steels is that they reduce machining time and cost. These steels permit faster metal removal through the use of deeper cuts and higher cutting speeds, and require less driving power when being machined. Also, burring of teeth after cutting is often completely eliminated or at least greatly minimized.

Both the 1000 series of carbon steels and low alloy grades have been leaded with little change in tensile, bending and impact properties. In general, lead causes a 20% reduction in the fatigue strength of steels with a tensile strength of 265,000 psi, an 8% reduction in steels of 150,000 psi, and a negligible reduction in steels of 120,000 psi.

High manganese steels — High manganese-nickel alloy steels are noted for their high resistance to heat, wear and bending stresses. The teeth of gears made from 13% manganese steel, with or without nickel, bend under excessive loads but do not usually break. The tooth faces also become work hardened and polished after continuous use.

Inasmuch as the 13% manganese steel cannot be economically machined, the gears are usually cast to shape and finished by grinding. An addition of 4% nickel enables the alloy to resist changes in grain structure resulting from overheating.

Boron steels—The presence of boron in lean alloy steels improves their heat treatment properties and enables them to be used for highly stressed gears. These steels have a minimum content of 0.0005% boron which is added as an intensifier to insure adequate hardening during quenching. Typical of the carburizing boron steels are: 46B12H, 94B15 and 94B17H. Typical through hardening types are: 50B46H, 81B45H and 86B45H.

Stainless steels—Stainless steels of the martensitic type are principally used for gears requiring a high degree of corrosion resistance. As shown in Table 4, these materials also possess excellent mechanical properties.

High strength steels — Ultra high strength steels with increased silicon and manganese content hold considerable promise for gears where maximum ductility is required at tensile strengths of 230,000 psi and over. These steels still retain their ductility when heat treated to as high as 285,000 psi. They may be considered as modified 4300 series steels with or without other alloying elements such as boron, vanadium and aluminum. Typical properties are listed in Table 5.

Preheat treated bar steels—A

Properties and selection of cast irons for gears

TABLE 7—TYPICAL MECHANICAL PROPERTIES OF STANDARD GRAY IRONS

ASTM Class ⬇	Tensile Strength, psi	Compressive Strength, psi	Torsional Shear Strength, psi	Modulus of Elasticity, 10^6 psi		Reversed Bending Fatigue Limit, psi	Brinell Hardness
				Tension	Torsion		
20	22,000	83,000	26,000	9.6–14.0	3.9–5.6	10,000	156
25	26,000	97,000	32,000	11.5–14.8	4.6–6.0	11,500	174
30	31,000	109 000	40,000	13.0–16.4	5.2–6.6	14,000	201
35	36.500	124,000	48,500	14.5–17.2	5.8–6.9	16,000	212
40	42,500	140,000	57,000	16.0–20.0	6.4–7.8	18,500	217
50	52,500	164,000	73,000	18.8–22.8	7.2–8.0	21,500	228
60	62,500	187,500	88,500	20.4–23.5	7.8–8.5	24,500	252

TABLE 8—RECOMMENDED OPERATING CONDITIONS FOR NICKEL CAST IRON GEARS

Properties Needed ⬇	Composition, %						Average Brinell Hardness[b]
	Total Carbon	Nickel	Silicon[a]	Manganese	Chromium	Molybdenum	
Moderate Strength and Wear Resistance	3.2-3.4	1.0–1.2	2.1–2.3	0.60–0.90	0.30–0.40	—	215
	3.2-3.4	1.0–1.2	1.7–1.9	0.60–0.90	—	—	215
	3.2-3.4	1.4–1.6	2.0–2.2	0.60–0.90	0.20–0.30	0.3–0.5	220
	3.2–3.4	1.4–1.6	1.7–1.9	0.60–0.90	—	0.3–0.5	220
Excellent Wear Resistance	3.5 min	1.8–2.0	1.3–1.5	0.65–0.85	0.20–0.40	0.4–0.6	220
	3.3 min	1.8–2.0	1.4–1.6	0.65–0.85	0.20–0.40	0.4–0.6	235
Good Wear Resistance and High Strength	3.0–3.2	1.8–2.0	1.8–2.0	0.65–0.85	0.20–0.30	0.6–0.8	235
	3.0–3.2	2.0–2.2	1.4–1.6	0.70–0.90	—	0.6–0.7	235
	3.0–3.2	1.2–1.4	1.8–2.0	0.70–0.90	0.20–0.30	0.2–0.3	227
Very High Strength	2.4–2.8	1.0–1.2	2.4–2.8	0.80–1.00	0.10–0.20	1.0–1.2	300
	2.6–2.8	1.2–1.4	1.9–2.3	0.80–1.00	0.15–0.25	0.4–0.6	300

[a] Silicon contents are for ¾ and 1¼-in. sections. For lighter sections, higher silicon contents are advisable; for heavier sections, lower silicon contents are advisable.

[b] Mean of values taken over range of section thickness.

TABLE 9—PROPERTIES OF AS-CAST MEEHANITE

Type ➡	GA	GC	GE
Tensile Strength, psi	50,000	40,000	30,000
Transverse Strength, lb	3,400	3,100	2,300
Shear Strength, psi	48,000	40,000	30,000
Brinell Hardness	207	192	174

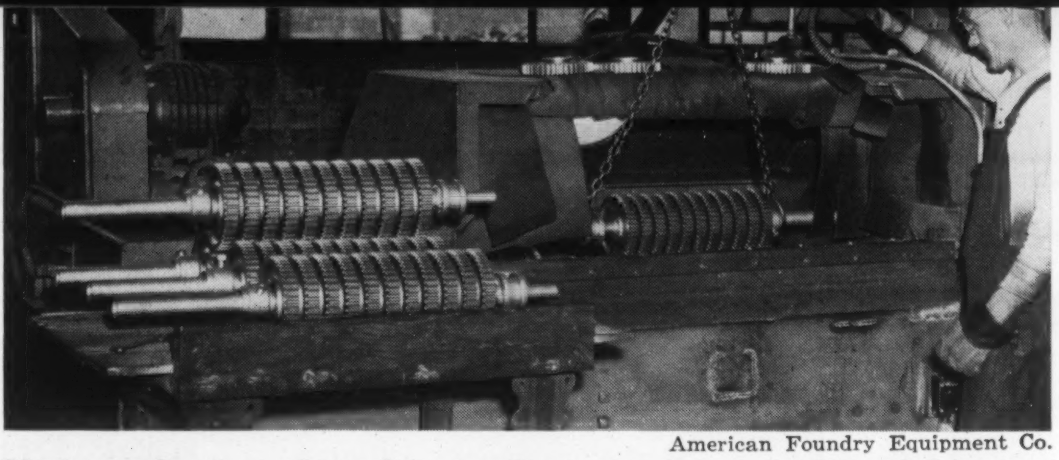
TABLE 10—PROPERTIES OF DUCTILE IRON GEAR MATERIALS

Type ➡	60–45–10	80–60–03	100–70–03	120–90–02
Tensile Strength, psi	60–80,000	80–100,000	100–120,000	120–150,000
Yield Strength, psi	45–60,000	60–75,000	70–90,000	90–125,000
Elongation in 2 in., %	10–25	3–10	3–10	2–7
Brinell Hardness	140–190	200–270	240–300	270–350
Charpy Impact Strength (unnotched), ft-lb	60–115	15–65	35–50	25–40

number of proprietary bar steels are available for gears that cannot be heat treated subsequent to machining. These steels (see Table 6 for properties) are used where distortion cannot be tolerated, where tolerances are small, or where grinding to close tolerances is impractical. They are obtainable in hardnesses up to 400 Brinell and can be machined to very close o.d. dimensions.

Cast irons

Gray and alloy irons—Cast iron provides three principal advantages when used as a gear material. These are: 1) low cost, 2) good damping capacity, and 3) good wear resistance when properly lubricated. The material is used in many applications where strength is not too important but good wear resistance is required. In such applications the high carbon irons are usually specified because of the presence of large amounts of graphite, which acts


American Foundry Equipment Co.

Shot peening *is used to relieve tensile stresses in gear surfaces and improve fatigue resistance.*

as a lubricant and improves wear resistance.

Cast iron is relatively weak and brittle when compared with rolled, forged or cast steel and has a low modulus of elasticity (10-20 x 10^6 psi). Because of shrinkage and porosity tendencies, the quality of cast iron gears is also dependent to a large degree on foundry practice.

Cast iron gears requiring maximum dimensional stability should be specified with a stress relieving treatment consisting of: 1) heating to a minimum temperature of 900 F for 1 hr per in. of section, and 2) furnace cooling at a rate not exceeding 50 deg per hr to a temperature of 200 F or less. Where improved hardness, wear resistance and strength are required, gears of simple shape and section can be oil quenched from 1550-1600 F and tempered at 700 to 1000 F. Depending on composition and drawing temperature, hardness is approximately doubled and tensile strength increased by 20 to 30% after heat treatment.

Typical mechanical properties of the ordinary grades of cast iron are listed in Table 7. The alloy cast irons, such as nickel, nickel-chromium, nickel-chromium-molybdenum, are usually used where greater strength, hardness and wear resistance are required. Compared to the ordinary gray irons, these materials provide a higher ratio of endurance limit to tensile strength, relatively low notch sensitivity, and a finer-grained, denser structure.

The various grades of nickel cast iron gears recommended for specific operating conditions are listed in Table 8. In general, the plain nickel and nickel-molybdenum gray irons are most satisfactory where gears are subjected to impact loading. The nickel-chromium and nickel-chromium-molybdenum types are best suited for constant load applications requiring high wear resistance.

A type of cast iron known commercially as Meehanite is also supplied for gear applications. Typical properties of three different grades of this material are listed in Table 9.

Corrosion resistant austenitic cast iron is used in many special applications such as pump gears for handling corrosive liquids. Typical of this grade of cast iron is Ni-Resist, an alloy containing 2% chromium, 6 copper, 15 nickel, 3 carbon, 2 silicon, 1% manganese, and balance iron.

Ductile iron—Ductile iron has also proved quite successful as a gear material because of its desirable combination of properties. Its combination of good casting and machining characteristics and high strength provides important cost and strength advantages. Ductile iron gears respond well to heat treatment, are wear resistant, and are dependable power transmission elements.

Typical mechanical properties of four types of ductile iron for gears are given in Table 10. Modulus of elasticity of the materials is about 25 x 10^6 psi, as compared to 30 x 10^6 for steel, and is substantially higher than that of ordinary gray iron.

Bronzes

Various types of bronzes are used for gears. Gear bronzes are typed according to their major alloying element such as tin, silicon, phosphor, lead, manganese, aluminum and nickel bronzes, and beryllium copper. Properties vary with the kind and amount of alloying elements and with the type of heat treatment. Only the aluminum bronzes and beryllium copper respond to heat treatment for improved mechanical properties.

Tin bronze — Because of their good combination of properties, including good hardness, strength and resilience, the tin bronzes are recommended for general purpose worm wheels. These materials have a tensile strength of about 40,000 psi with 20% elongation.

Since an increase in tin content over 10% causes a decrease in tensile strength, ductility and shock resistance, the tin content of gear bronzes is limited to a maximum of 12%. Phosphorus content is limited to that amount that will insure good fluidity. Phosphorus is a powerful hardener in that it forms a hard load bearing constituent which, however, is quite brittle.

A lead content over 0.5% lowers the yield point in compression and tends to promote pitting. Nickel raises the yield point in compression and thereby helps to resist pitting. It also increases tensile and impact strength.

Silicon bronzes—These materials are usually used for worm wheels that mate with case hardened worms, and are recommended for medium loads, medium-to-high speeds and severe service. Their average tensile strength is about 50,000 psi and their elongation is 15%.

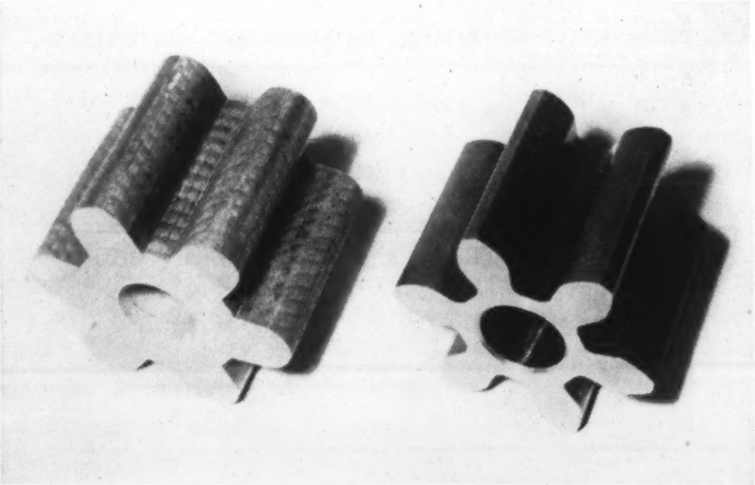
Phosphor bronzes — Phosphor bronzes are also recommended for worm wheels to mate with hardened steel worms of high hardness and fine accuracy. They can be used under conditions of severe service, medium loads, and medium to high speeds. Phosphor bronzes of 86-89 copper, 9-11 tin, 1-3 zinc, 0.2 lead and 0.02% phosphorus are recommended for severe working conditions and heavy pressures.

Leaded bronzes—Leaded bronzes containing 78-91 copper, 9-11 lead, 0.5-1.0 zinc and 0.25% phosphorus are recommended for worm gears to mate with soft steel worms under low loads and low to medium speeds. These materials have a tensile strength of 25,000 psi and an elongation of 80%.

Manganese bronzes—Manganese bronze with a content of 59 copper, 39 zinc, 1 tin, and 1% iron is recommended for spur and bevel gears used at low speeds and low tooth pressures. A high manganese bronze containing 3-4 manganese, 2-4 aluminum and 1-1.5% iron is recommended for severe service, high loads and high speeds. This bronze is highly wear resistant and has a tensile strength of 90,000 psi with a Brinell hardness of 120.

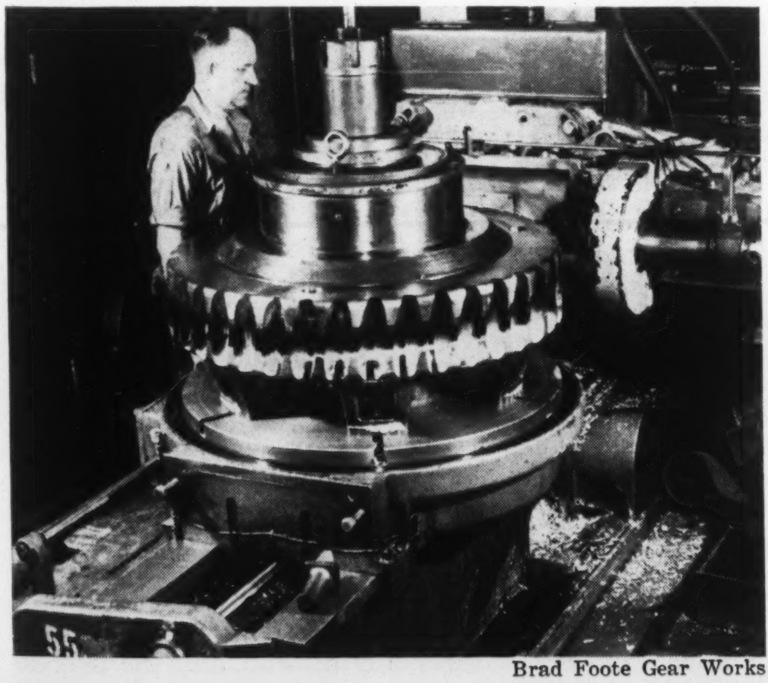
Aluminum bronzes—These materials (see Table 11) combine high strength and hardness with good resistance to wear and fatigue. Aluminum bronze gears are particularly suited for severe service where long life is required. Because of their high hardness they are especially recommended where gears are subject to grit, dust and scale. Also, because of

Bronze gears have good wear resistance



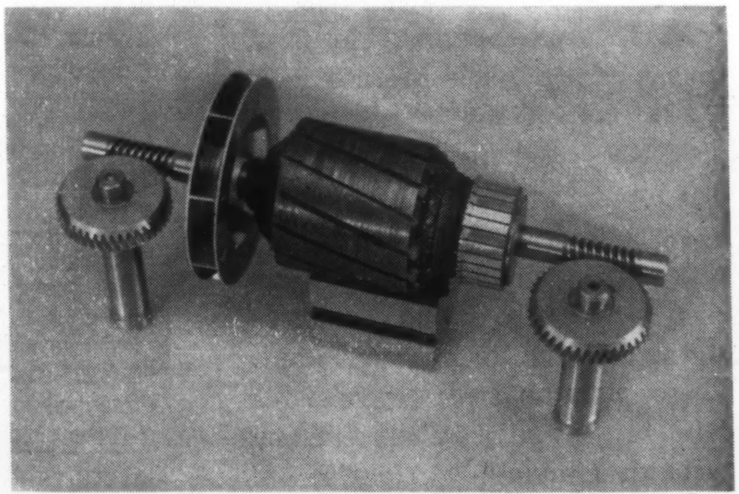
American Smelting and Refining Co.

Continuous cast bronze *stock (left) is used for pump rotors. Only one rough cut and one fine cut are made on teeth (right) before use.*



Brad Foote Gear Works

SAE 62 bronze *worm gear is used in large steel mill drive.*

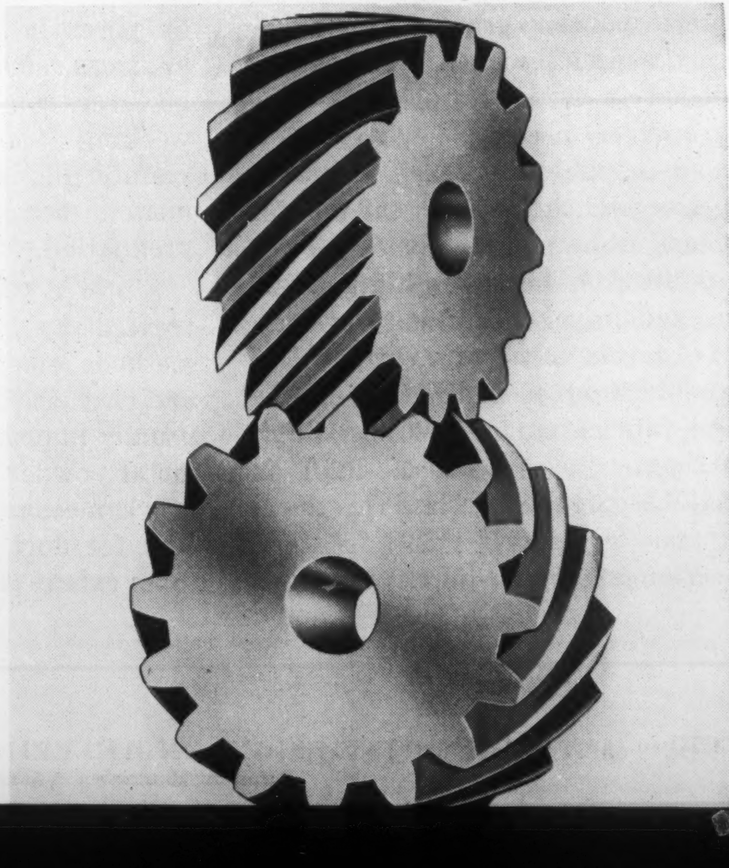


American Smelting and Refining Co.

Bearing bronze *alloy gears drive armature of floor polisher motor.*

SAE 65 bronze *is used for lower gear and induction hardened 4140 steel for upper gear of this spiral gear set. Combination of two materials reduces friction and eliminates possibility of seizing.*

Philadelphia Gear Works, Inc.



their high strength, they are suitable for gears that are subject to shock and overloads.

Aluminum bronzes and aluminum-nickel bronzes are used for highly stressed worm wheels designed to mate with hardened steel worms. They are also used for spur and bevel gears designed to mate with hardened steel pinions under severe service and heavy loads.

Aluminum bronzes with high aluminum content and iron additions respond favorably to a strengthening heat treatment. Bronzes with a low aluminum content cannot be heat treated satisfactorily. In general, the low-aluminum bronzes are satisfactory for slow moving gears, but are not recommended for worm wheels subject to high friction loads.

Nickel bronzes—Nickel bronzes, such as the Ni-Vee bronzes with 5% nickel, possess a number of properties that recommend their use for gears that are subject to heavy and irregular loading. As shown in Table 12, they possess good yield strength and toughness and are also quite wear resistant. Their superior as-cast properties can be elevated still further through simple heat treatments which control a nickel-tin-copper precipitation reaction.

Properties of gear bronzes

TABLE 11—TYPICAL PROPERTIES OF ALUMINUM BRONZE GEARS

Alloy	Condition	Tensile Strength, psi	Yield Strength, psi	Elongation in 2 in., %	Brinell Hardness (3000-kg load)
89.5 Cu-9.5 Al-1.0 Fe	Sand Cast	73,000	30,000	35	120
	Heat Treated	85,000	44,000	26	150
88.5 Cu-10.5 Al-1.0 Fe	Sand Cast	75,000	42,000	16	136
	Heat Treated	88,000	46,000	14	172
88.5 Cu-8.6 Al-2.9 Fe	Sand Cast	65,000	24,000	25	116
	Hot Rolled	100,000	60,000	20	180
88.5 Cu-10.2 Al-3.3 Fe	Sand Cast	75,000	34,000	20	145
	Centrifugal Cast	82,000	37,500	18	150
85.0 Cu-11.0 Al-3.7 Fe	Heat Treated	95,000	50,000	7	215
81.3 Cu-10.7 Al-4.0 Fe-4.0 Ni	Heat Treated	100,000	55,000	12	220

TABLE 12—TYPICAL PROPERTIES OF NICKEL BRONZE GEAR MATERIALS

Alloy ➡	Ni-Vee A[a]			Ni-Vee B[b]	
	As Cast	Tempered	Heat Treated	As Cast	Tempered
Tensile Strength, psi	50,000	65,000	85,000	45,000	60,000
Yield Strength, psi	22,000	40,000	55,000	20,000	30,000
Elongation in 2 in., %	40	10	10	30	8
Reduction of Area, %	50	—	26	—	—
Brinell Hardness	85	130	180	80	120
Izod Impact Strength (unnotched), ft-lb	85	80	110	—	—

[a] 88 Cu-5 Ni-5 Sn-2% Zn.
[b] 87 Cu-5 Ni-5 Sn-2 Zn-1% Pb.

Metal Powders

The principal advantage of metal powder gears is their low cost, especially when they are produced in large quantities. They are widely used for low speed, low load applications such as idler gears. In the past metal powder gears were not recommended for applications involving high stresses and impact loading. However, the development of new powders and techniques has made possible the fabrication of low cost, high strength gears with as high as AGMA precision Class II tolerances.

Elongation and impact strength of sintered gears are often limited by pores in the metal which act as stress raisers. These properties, however, can be improved by cold working (coining) followed by resintering, and by the use of molten metal infiltration or impregnation.

Sintered steel gears can be heat treated by many of the same methods employed with wrought and cast gears. Quench hardening usually improves the properties of metal powder gears and may improve mechanical properties (except for ductility and toughness) to an extent that they match those of AISI wrought steels.

Iron-base gears can be surface hardened by carburizing (see "Carburized Iron Powder Parts," MATERIALS & METHODS, Apr '57, p 122), cyaniding and nitriding. The depth of a carburized case, of course, depends on the carburizing medium, temperature and time of treatment. Because of the porosity of metal powder gears it is quite difficult to control the depth and uniformity of the case, and it is possible for carbon to diffuse into the core. Control of cyaniding is especially difficult and the process appears to be suitable only for very high density gears. If porosity is too high, the cyaniding salts may penetrate the compact and cause internal corrosion.

High density gears with high tooth strengths can be obtained by the cementation process, in which the porous steel compact is impregnated or infiltrated with a molten metal such as a copper alloy. These gears are virtually free from pores and have a tensile strength in the range of 50,000 to 100,000 psi. They can be quenched, tempered or case hardened, and can be used at high stresses under heavy loads.

By taking advantage of the flexibility of die designs, it is possible to combine cams, clutches and driving devices with metal powder gears. It is also feasible to incorporate keyways, splines and flats in gear bores. A gear and pinion cluster combination is commonly used. Various types of cams can also be made part of a gear component. Since selective hardening is feasible, it is also possible to harden the cam surface and leave the gear teeth soft to avoid distortion. The same techniques used for the selective hardening of any low carbon steel can be used with sintered iron.

Nonmetallics

Nonmetallic materials are selected for gears principally because of their silence of operation, resiliency, vibration damping properties and low cost in large quantities.

Molded plastics

A number of cotton and glass fiber-reinforced phenolic molding materials are used for gears. Cotton-filled phenolic gears are especially noted for their quiet operation, but their mechanical properties are not as good as those of glass-filled gears. Glass-filled gears possess a number of desirable properties including: 1) resistance to high and low temperatures, 2) high tensile and flexural strength, 3) high impact resistance, 4) good dimensional stability, and 5) good resistance to deformation under load.

Molded polystyrene materials are also available for gears. These materials have good dimensional stability over a wide humidity range.

Nylon—One of the most popular plastics molding materials available for gears is nylon. Because of their so-called self-lubricating properties, nylon gears do not require any lubrication and require little or no maintenance. The gears also have a low coefficient of dynamic friction, are quiet and exceptionally resilient, and possess good tensile, flexural and impact strengths. Nylon gears operate quite well against steel pinions, as well as against other nylon gears provided that they are not highly stressed or operated at elevated temperatures.

Because of their compliability, i.e., their ability to yield under pressure and return to their original state when pressure is released, nylon gears are able to absorb shock and to deform slightly under impact loads. This property also helps to compensate for any dimensional inaccuracies that crop up during molding.

When used within a safe working stress of 4500 to 4900 psi and below 150 F, nylon can often outperform steel. The material has excellent service life when used within its strength and heat range. However, because of their low heat conductivity (1.7 Btu/sq ft/hr/°F/in.), nylon gears may be subject to deformation and undue wear because they are not able to dissipate heat fast enough. For this reason it may be necessary to provide some means of heat dissipation.

Some geometric corrections are usually required on tooth profiles of nylon gears to compensate for mold shrinkage. It is a well-known fact that nylon absorbs moisture. For this reason sufficient back lash should be allowed in the teeth to compensate for swelling under high humidity conditions.

It is possible to compensate for swelling by immersing the material in water (preferably at elevated temperatures) until its weight increases by 2½%. Since gears treated in this manner have already been subjected to moisture swelling, their dimensions are less likely to change during actual operation at high humidities.

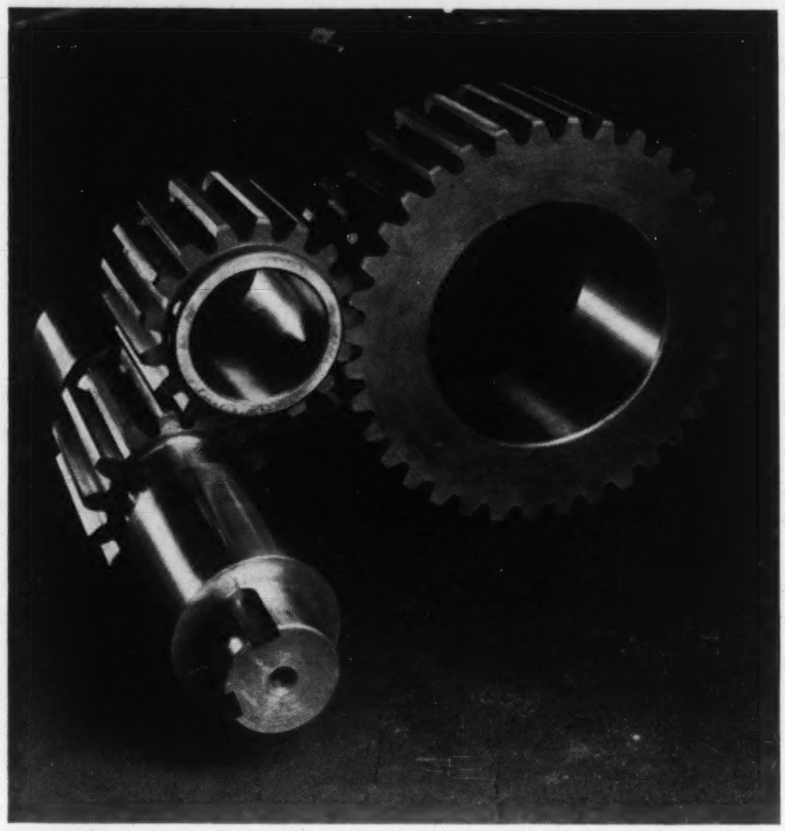
Reinforced laminates

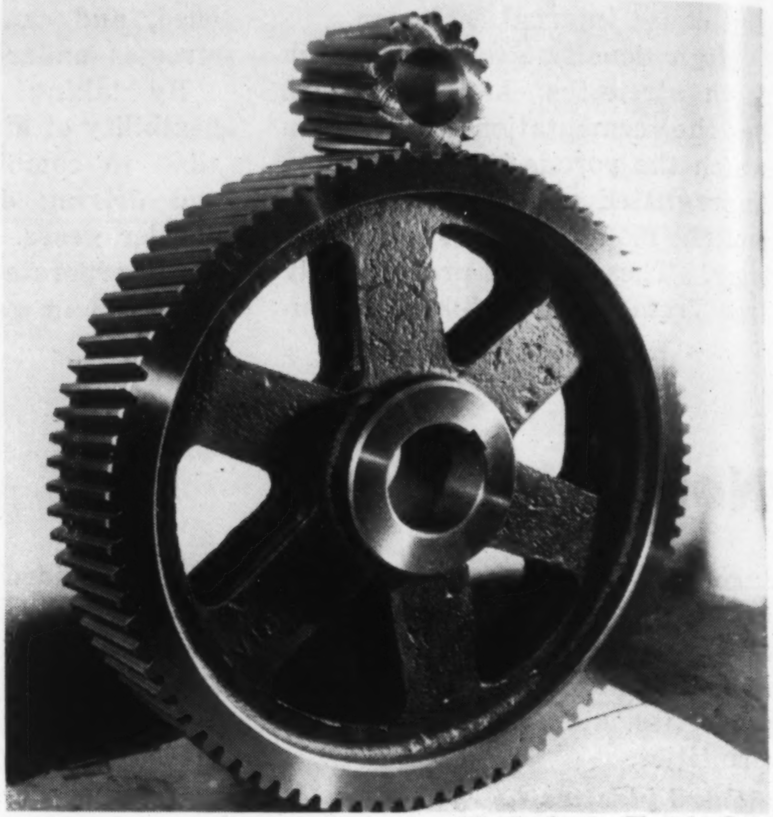
In general, the properties of reinforced plastics laminate gears are the same as those of reinforced molded gears. Reinforced laminates are produced by impregnating a reinforcing material with a thermosetting resin, laminating the material into multiple layers, and curing with heat and pressure to form a dense, hard solid with good mechanical strength.

A cotton or linen fabric (or occasionally paper) impregnated with a phenolic resin is probably the most popular combination of reinforcing material and resin used in laminated gears. Materials of this type possess a number of significant properties including: 1) good shock resistance, 2) high resiliency, 3) low dynamic coefficient of friction on hardened steel, 4) good wear resistance, 5) good dimensional stability, 6) high resistance to corrosive atmospheres and liquids, 7) low weight and low moment of inertia, and 8) good machinability (the material can be sawed, sheared, punched, milled, hobbed, drilled and tapped).

As a rough guide in determining if a laminated gear will be strong enough for a given application it can be assumed that the material's power transmission capacity is approximately the same

This text continues on p 164; gear types on next two pages





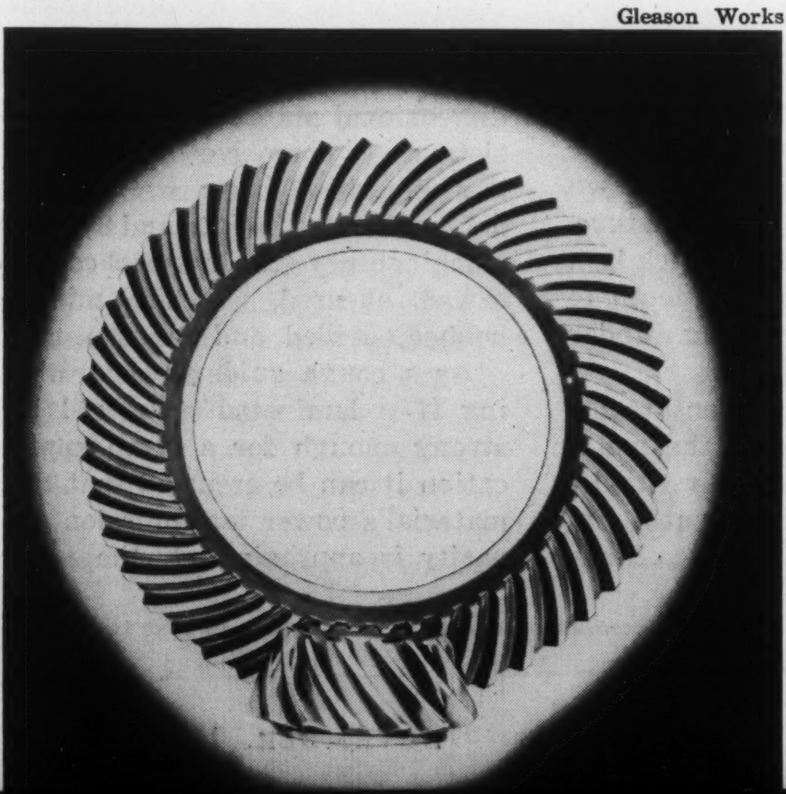
Westinghouse Electric Corp.

Spur gears are the most commonly used type. Essentially a spur gear is a cylinder or wheel whose surface contains a series of teeth parallel to each other and to the main cylinder axis. Spur gears have an average efficiency of 80% and are used principally to transmit power between parallel axes. They are most commonly used in industrial machines at moderate speeds and medium loads. These gears are not as quiet or as strong as helical or herringbone gears of equal size.

Helical gears resemble spur gears in that the teeth are cut on a cylindrical body, but differ from spur gears in that the teeth are spiraled around the body. Spiraling provides smooth operation and minimum noise. The teeth mesh progressively and drive with an even power flow. Helical gears are stronger than spur gears of equal size. Chief objection to helical gears is that the angular drive develops an end thrust which imposes heavy strain on the side of the gear receiving the thrust.

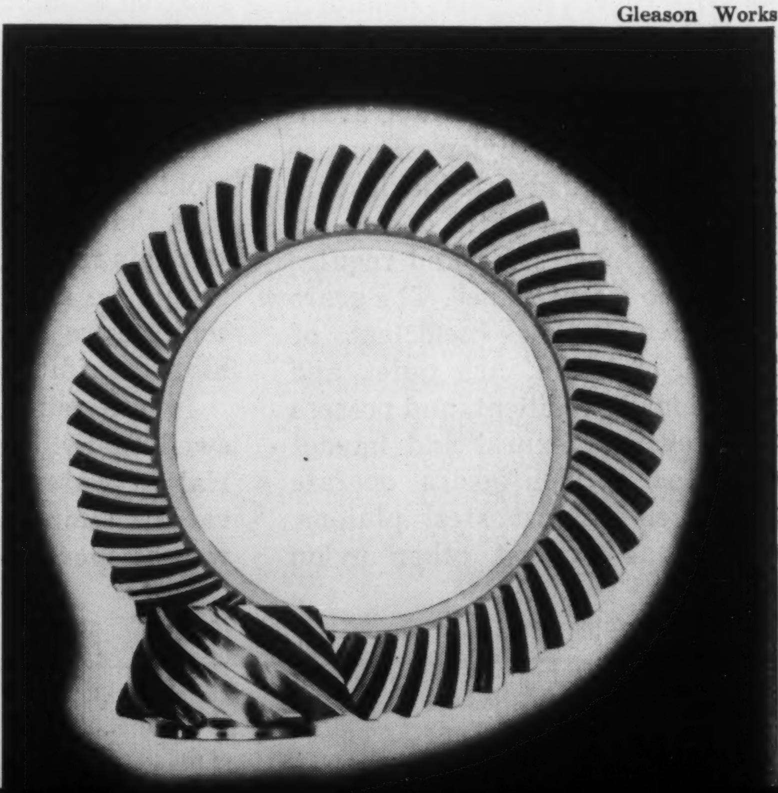
Spiral bevel gears are similar to straight bevel gears except for their tooth shape which is curved or spiraled. They are superior to straight bevel gears in that loads are always distributed over two or more teeth at any given time. They are also smoother and quieter because the teeth mesh together progressively. Because of their curved teeth, spiral bevel pinions may be designed with fewer teeth than straight bevel pinions of comparable size.

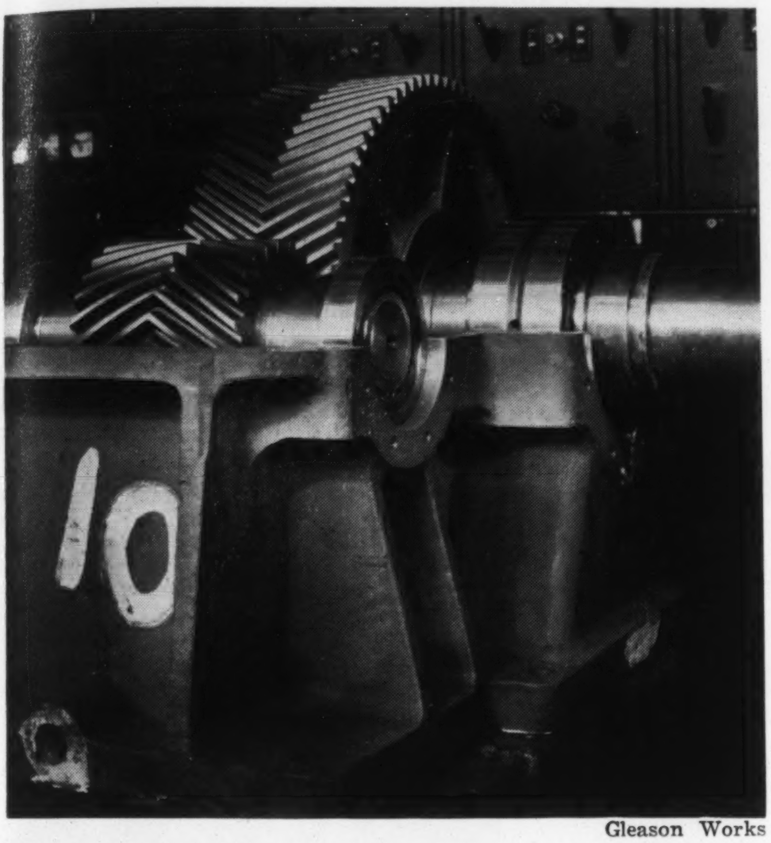
Gleason Works



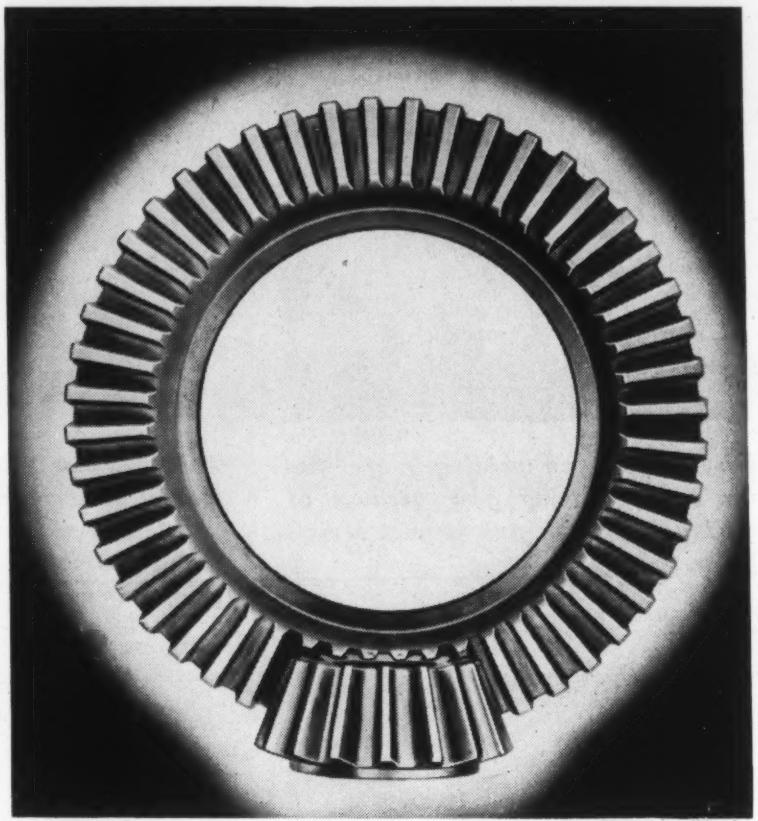
Hypoid gears look like spiral bevel gears but differ in that their centerlines do not intersect. The action between teeth is a combination of the rolling action of bevel teeth and the sliding of worm gear teeth. Magnitude of the sliding action depends on the amount of offset. The teeth engage progressively and there are always two or more pairs of teeth in contact. In general, hypoid gears are stronger and operate more smoothly than spiral bevel gears.

Gleason Works





Gleason Works



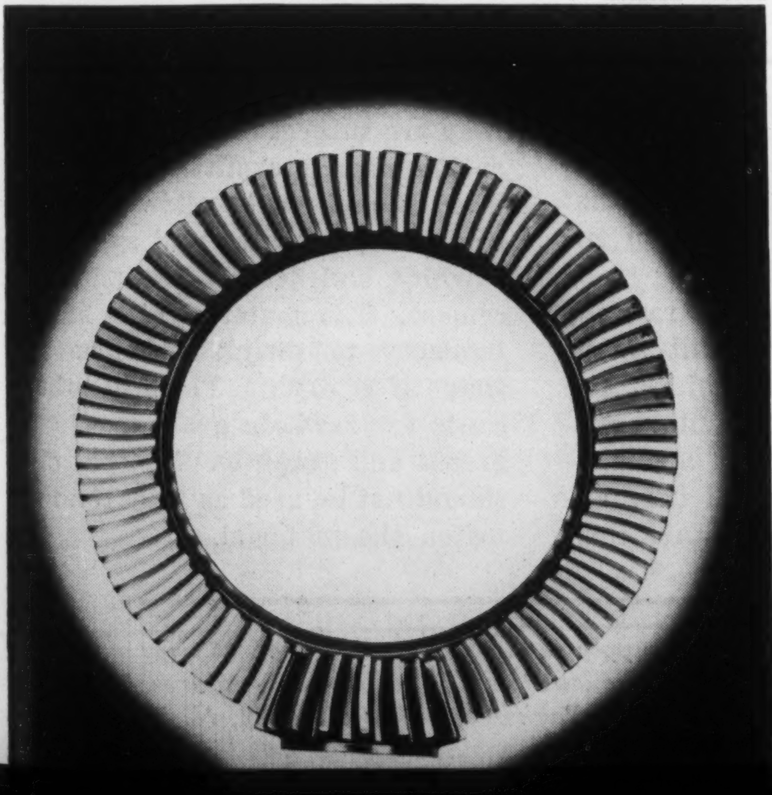
Gleason Works

Herringbone gears resemble two helical gears placed side by side so that the teeth come together to form a chevron pattern. These gears operate very smoothly with a minimum of noise, backlash and vibration. They have relatively high strength because of the double angle tooth formation and because the load is distributed over the full width of the tooth. They also eliminate shocks and neutralize end thrust, and are used principally for heavy duty, high speed drives.

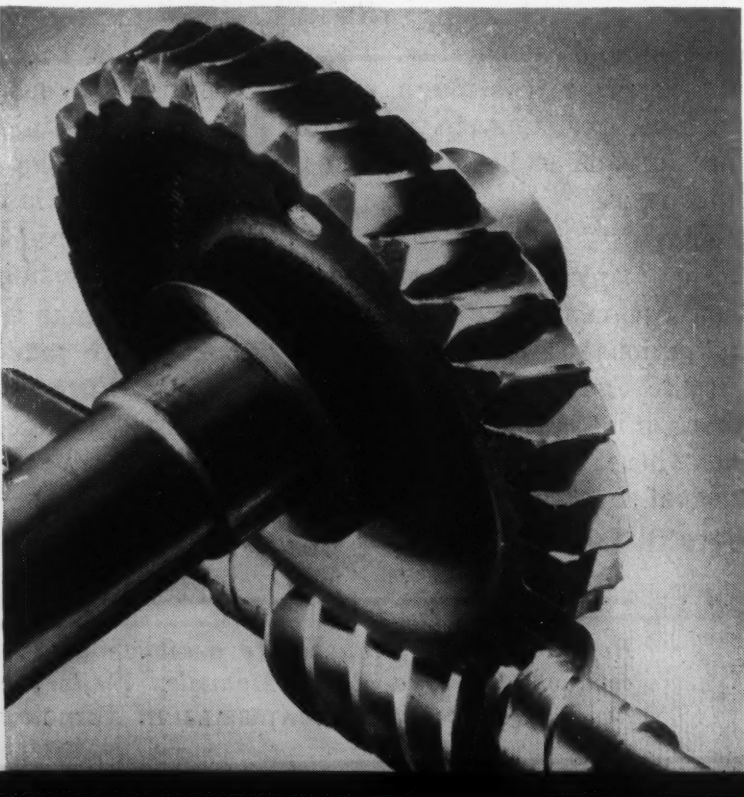
Bevel gears are used for transmitting power between shafts at an angle (usually 90 deg). The teeth are cut on the angular surface of a truncated cone and may be straight or spiraled. So-called miter gears are essentially bevel gears in which both units of a pair have the same diameter and number of teeth. They are used to transmit power at right angles where no reduction of speed is required. Skew bevel gears are used to connect shafts which are not parallel and do not intersect.

Zerol gears are essentially spiral bevel gears which have a zero spiral angle. They are superior to straight bevel gears in that they run smoother and quieter due to the curvature and slight overlap of the teeth. Their principal advantage over spiral bevel gears is that, because of their zero spiral angle, they do not develop any inward axial thrusts. They are replacing straight bevel gears in many applications because of their superior operating characteristics and longer life.

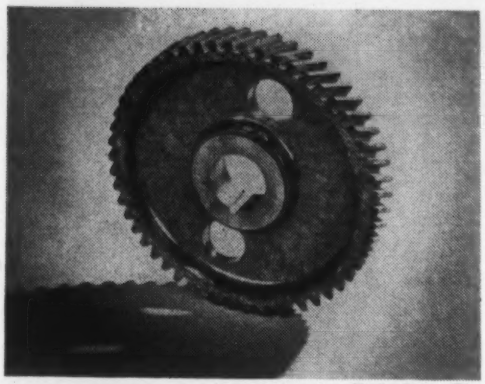
Gleason Works



Worm gears are used for transmitting power between shafts at right angles. The teeth on the worm slide against the gear teeth and at the same time produce a rolling action. Because of this screw action, worm gear drives are quiet and free from vibration and pulsation. Worm gears are subject to high tooth pressures and considerable heating and abrasion at the point of contact. They are widely used in applications where large changes in velocity are required.

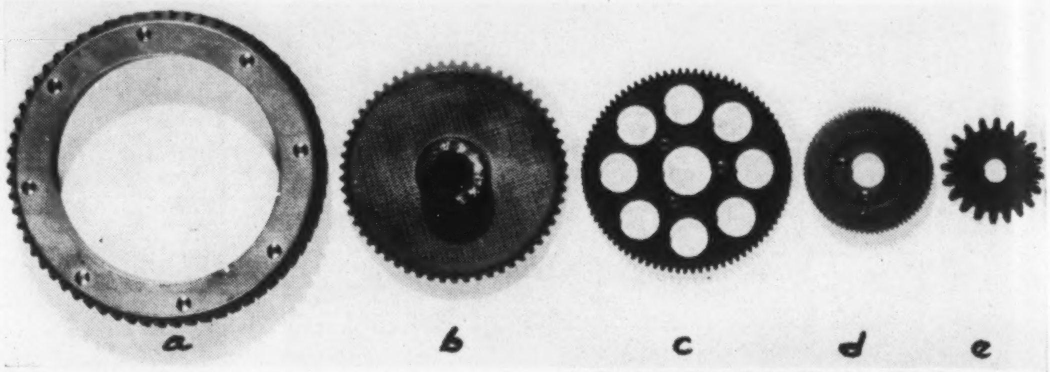


Nonmetallic gears provide quiet operation



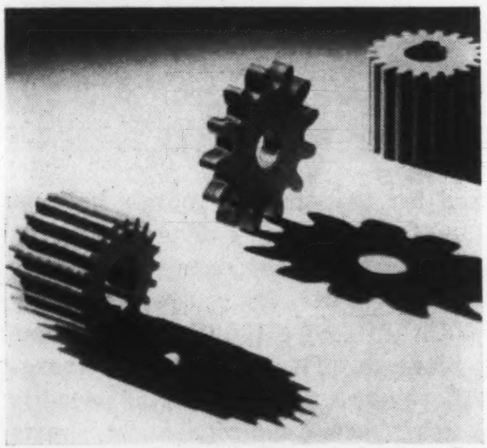
Bakelite Co.

Phenolic-glass *molding is specified for engine timing gear because of its high strength and impact resistance.*



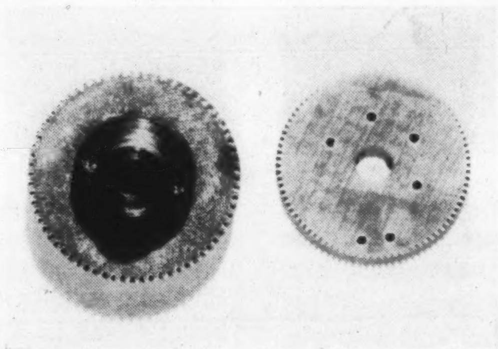
Quaker City Gear Works; Synthane Corp.

Cotton-base phenolic *laminate gear (A) with structural brass plates is used in voice recording instrument. Canvas-base gear (B) is used in noiseless elevating equipment. Fabric-base gear (C) is used in electronic instruments. Nylon fabric laminate gear (D) is part of motion picture sound projector. Similar gear (E) is used for television set control.*



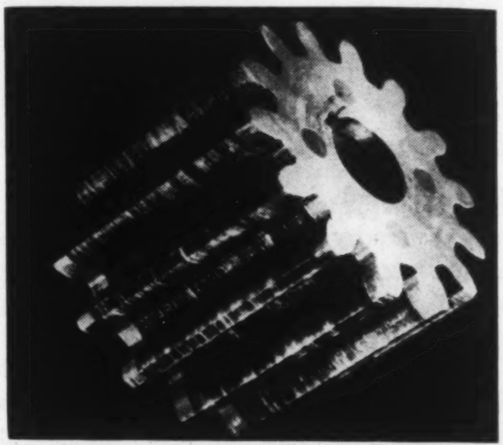
National Vulcanized Fibre Co.

Vulcanized fibre *gears are tough, easy to machine, wear well and operate quietly.*



Process Gear Co., Inc.; Synthane Corp.

Fabric-base *phenolic laminate gear (left) is used as feed and take-up sprocket gear in motion picture projector. Paper-base laminate gear (right) is used in 16-mm motion picture camera.*



Chicago Rawhide Co.

Rawhide *gears are specified for their excellent shock resistance and quiet operation.*

as that of cast iron.

In addition to the above phenolic laminates, vulcanized fibre is also used for gears. This material is made by laminating chemically gelled paper, leaching out the chemical and calendering. The resulting material is tough, easy to machine, resistant to wear and abrasion and makes an extremely quiet gear.

Rawhide

For many years rawhide has been a popular material for gears and pinions designed to mate with metallic gears in applications where quiet operation is required and where teeth must withstand unusual shock. To obtain a noiseless gear drive, it is necessary only to use one rawhide gear in a pair of gears. Because of the relatively high cost of rawhide it is usually specified for the smaller gear. A cast iron gear is usually used for the mating gear because of its low cost and because it will transmit about the same load that a rawhide pinion of like pitch will transmit. The strength of a rawhide pinion is about 65% of that of a cast iron spur pinion of the same dimensions.

The blanks from which rawhide gears are made are built up of layers of prepared steer hides. The laminations are coated with a special adhesive compound and subjected to pressure until they adhere firmly. The blanks are then assembled with rivets and brass or steel flanges which serve to protect and support the material. After assembly, blanks are turned to size on a lathe and then milled.

Despite their resilience and elasticity, rawhide gears should not be used in applications where they are subject to severe reciprocating or intermittent motion. They should not be allowed to become wet, as water will swell the rawhide and destroy the bonding cement. The material also has a tendency to shrink and lose its shape after drying. The best lubricants for rawhide gears are hard grease and graphite. Mineral oils should not be used as they tend to soften the material.

Reprints of this Manual are available at 35¢ each until supply is exhausted. See page 254 for complete list of available Manuals. Write for quotations on quantities of 100 or more. Address Reader Service Dept., MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

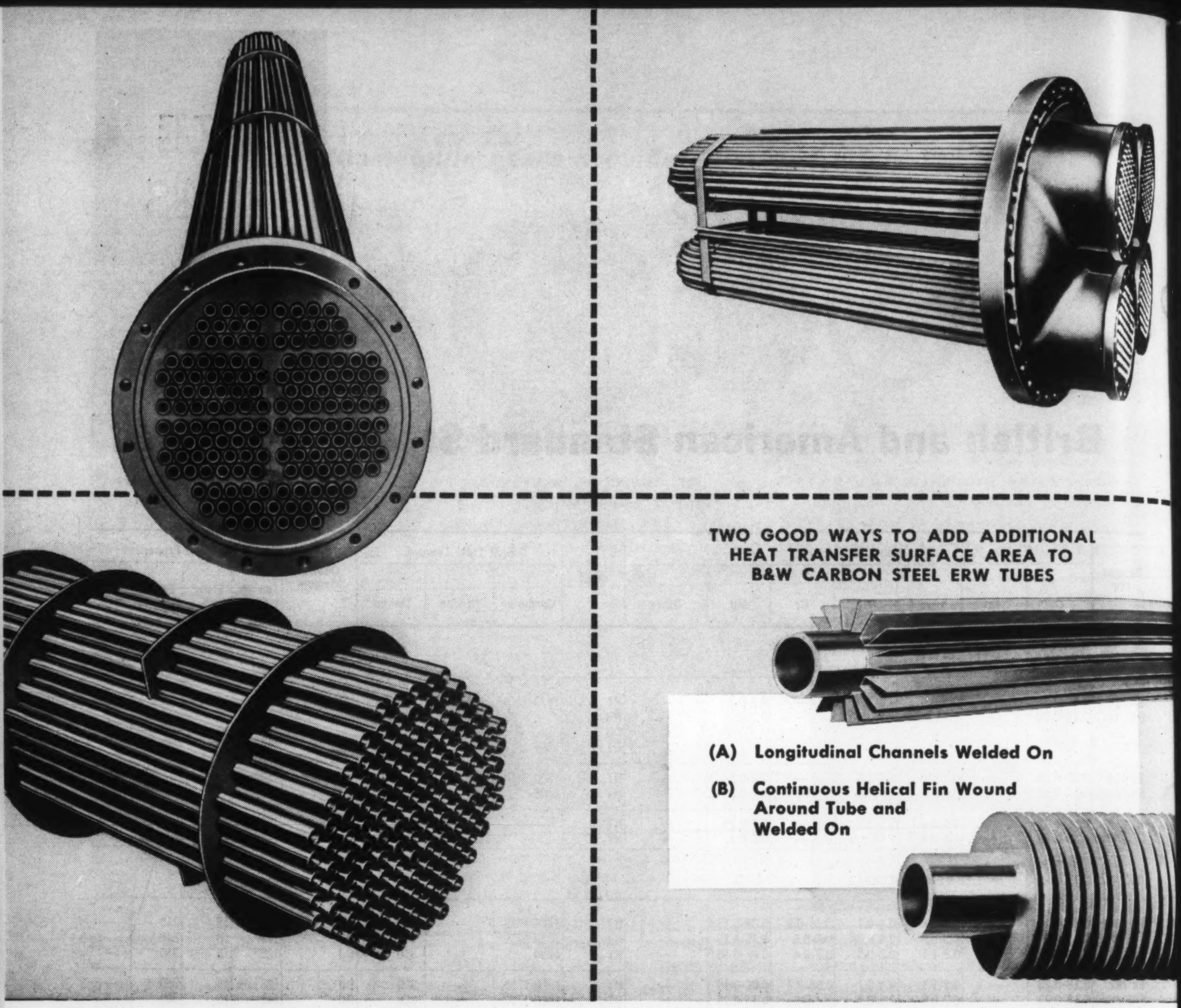
British and American Standard Steels—continued*

Designation	Composition, %							Cond	Heat Treat Temp, F			Quench Medium	Mechanical Properties			
	C	Si	Mn	Ni	Cr	Mo	Other		Carburize	Harden	Temper		Ten Str, 1000 psi	Elong, %	Brinell Hardness	Ruling Section in.
NICKEL-MOLYBDENUM STEELS																
En 34	0.14-0.20	—	0.3-0.6	1.5-2.0	—	0.2-0.3	—	HT......	1620-1710	1400-1440	—	Oil	100 min	18 min	—	—
SAE 4617	0.15-0.20	—	0.45-0.65	1.65-2.0	—	0.2-0.3	—	HR......	—	—	—	—	83	27	163	—
								CD......	—	—	—	—	108	14	212	—
								HT......	1700	—	300	Oil	140	20	290	—
En 35A	0.20-0.25	—	0.2-0.6—	1.5-2 0	—	0.2-0.3	—	HT......	1620-1710	1400-1440	—	Oil	123 min	15 min	—	1½
SAE 4620	0.17-0.22	—	0.45-0 65	1.65-2.0	—	0.2-0.3	—	HT......	1700	—	30	Oil	.52	18	320	1⅛
En 160	0.35-0.45	—	0.3-0.6	1.5-2.0	—	0.2-0.35	—	HT......	—	1525-1580	1020-1220	Oil	100-134	17-20	200-320	1⅛-6
SAE 4640	0.38-0.43	—	0.6-0.8	1.65-2.0	—	0.2-0.3	—	HT......	—	1525	1020	Oil	148	16	300	—
NICKEL-CHROMIUM-MOLYBDENUM STEELS																
En 361	0.13-0.17	—	0.7-1.0	0.4-0.7	0.55-0.8	0.08-0.15	—	HT......	1620-1710	—	300	Oil	100 min	18	210	—
SAE 8615	0.13-0.18	—	0.7-0.9	0.4-0.7	0.4-0.6	0.15-0.25	—	HT......	1620-1710	—	300	Oil	118	18	240	—
SAE 9415	0.13-0.18	—	0.8-1.1	0.2-0.5	0.2-0.4	0.08-0.15	—	HT......	1700	—	340	Oil	125	16	250	—
En 362	0.18-0.23	—	0.7-1.1	0.4-0.7	0.55-0.8	0.08-0.15	—	HT......	1620-1710	—	300	Oil	123 min	15	250	—
SAE 8620	0.18-0.23	—	0 7-0.9	0.4-0.7	0.4-0.6	0.15-0.25	—	HT......	1620-1710	—	300	Oil	145	16	300	—
SAE 9420	0.18-0.23	—	0.8-1.1	0.2-0.5	0.2-0.4	0.08-0.15	—	HT......	1700	—	300	Oil	155	13	320	—
En 363	0.22-0.26	—	0.7-1.0	0.4-0.7	0.55-0.8	0.08-0.15	—	HT......	1620-1710	—	300	Oil	145 min	10	300	—
SAE 9422	0.22-0.25	—	0.8-1.1	0.2-0.5	0.2-0.4	0.08-0.15	—	HT......	1700	—	300	Oil	164	10	330	—
En 325	0.2 max	—	0.45-0.65	1.5-2.0	0.4-0.6	0.2-0.3	—	HT......	1620-1710	—	300	Oil	123 min	15	250	—
SAE 4317	0.15-0.20	—	0.45-0.65	1.65-2.0	0.4-0.6	0.2-0.3	—	HT......	1700	—	300	Oil	166	13	340	—
En 100[d]	0.35-0.45	—	1.2-1.5	0.5-1.0	0.3-0.6	0.15-0.25	—	HT......	—	1560	1020-1220	Oil	100-145 min	16-22	200-340	1-4
SAE 9442	0.4 -0.45	—	1.0-1.3	0.3-0.6	0.3-0.5	0.08-0.15	—	HT......	—	1525	1000-1200	Oil	108-152	13-20	220-310	—
En 110	0.35-0.45	—	0.4-0.8	1.2-1.6	0.9-1.4	0.1-0.2	—	HT......	—	1525-1580	1220 max	Oil	112-157	15-20	220-370	1⅛-6
En 24	0.35-0.45	—	0.45-0.7	1.3-1.8	0.9-1.4	0.2-0.35	—	HT......	—	1510-1560	1220 max	Oil	112-224	8-20	220-440	1⅛-6
SAE 4340	0.38-0.43	—	0.6-0.8	1.65-2.0	0.7-0.9	0.2-0.3	—	HT......	—	1545	1220 max	Oil	134-213	12-20	270-430	—
En 25	0.27-0.35	—	0.5-0.7	2.3-2.8	0.5-0.8	0.4-0.7	—	HT......	—	1510-1560	1220 max	Oil	123-224	10-18	250-440	2½-6
En 26	0.36-0.44	—	0.5-0.7	2.3-2.8	0.5-0.8	0.4-0.7	—	HT......	—	1510-1560	1220 max	Oil	134-224	10-17	270-444	4-6
En 36©	0.12-0.18	—	0.3-0.6	3.0-3.75	0.6-1.0	0.1-0.25	—	HT......	1620-1710	—	300	Oil	145 min	13 min	300 min	—
SAE 9315	0.13-0.18	—	0.45-0.65	3.0-3.5	1.0-1.4	0.08-0.15	—	HT......	1700	—	300	Oil	214	15	430	—
En 27	0.25-0.35	—	0.7 max	3.0-3.75	0.5-1.3	0.2-0.65	—	HT......	—	1510-1560	1020-1220	Oil	123-157	15-18	250-375	4-6
En 28	0.25-0.40	—	0.7 max	3.0-4.5	0.75-1.5	0.2-0.65	—	HT......	—	1510-1560	930-1110	Oil	134-179	7-14	270-415	2½-6
En 39B	0.12-0.18	—	0.5 max	3.8-4.5	1.0-1.4	0.15-0.35	—	HT......	1620-1710	1400-1440	390 max	Oil	140 min	12 min	390 min	—
En 30B	0.26-0.34	—	0.4-0.6	3.9-4.3	1.1-1.4	0.2-0.4	—	HT......	—	1490-1525	480 max	Air or oil	224 min	10 min	444 min	6

* *See last month's issue (Oct '57), p 171 ff, for first four pages and all footnotes. Complied by W. B. Kemmish, Consulting Metallurgist with Dr. R. Genders, London, England.*

(continued on p 169)

◀ **For more information, circle No. 579**



TWO GOOD WAYS TO ADD ADDITIONAL HEAT TRANSFER SURFACE AREA TO B&W CARBON STEEL ERW TUBES

(A) Longitudinal Channels Welded On

(B) Continuous Helical Fin Wound Around Tube and Welded On

TUBING REQUIREMENTS FOR HEAT TRANSFER EQUIPMENT

The economy and usefulness of pressure tubing in heat exchanger and condenser applications depend on the tubing's heat transfer ability and the ease with which it can be bent, coiled, swaged, and rolled into tube sheets.

Because of its uniform wall thickness, the heat transfer ability of B&W Electric-Resistance-Welded Carbon Steel Tubing is the optimum for such a ferrous material. It is an economical material to use, not only because of its reasonable first cost, but also because of its low fabrication cost, since ease of bending, coiling, swaging, and rolling into tube sheets is provided through quality-controlled methods used in its manufacture.

B&W Electric-Resistance-Welded Carbon Steel Heat Exchanger and Condenser Tubing is widely used in the process industries, including petroleum refining and chemical processing, and in refrigeration and steam generating equipment. If carbon steel tubing can do the job required, you will find B&W ERW Tubing provides maximum, trouble-free service life. For additional information, call on Mr. Tubes, your nearby B&W Tube Representative — *or write for Bulletin 412.* The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pa.

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Seamless and welded tubular products, seamless welding fittings and forged steel flanges—in carbon, alloy, and stainless steels

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British and American Standard Steels—continued

Designation	Composition, %							Cond	Heat Treat Temp, F			Quench Medium	Mechanical Properties			
	C	Si	Mn	Ni	Cr	Mo	Other		Carburize	Harden	Temper		Ten Str, 1000 psi	Elong, %	Brinell Hardness	Ruling Section, in.
MANGANESE-NICKEL-CHROMIUM STEELS																
En 351	0.20 max	—	0.6-1.0	0.6-1.0	0.4-0.8	0.10 max	—	HT......	1620-1710	1450-1510	—	Oil	100 min	18 min	—	—
En 352	0.20 max	—	0.5-1.0	0.85-1.25	0.6-1.0	0.10 max	—	HT......	1620-1710	1450-1510	—	Oil	123 min	15 min	—	—
En 353	0.20 max	—	0.5-1.0	1.0-1.5	0.75-1.25	0.08-0.15	—	HT......	1620-1710	1450-1510	—	Oil	145 min	12 min	—	—
En 354	0.20 max	—	0.5-1.0	1.5-2.0	0.75-1.25	0.1-0.2	—	HT......	1620-1710	1450-1510	—	Oil	168 min	12 min	—	—
En 355	0.20 max	—	0.4-0.7	1.8-2.2	1.4-1.7	0.15-0.25	—	HT......	1620-1710	1450-1510	—	Oil	140 min	12 min	—	—
CHROMIUM STEELS																
En 206	0.12-0.17	—	0.3-0.5	—	0.3-0.5	—	—	HT......	1620-1710	1400-1435	—	Water	85	24	180	—
En 207	0.16-0.21	—	0.6-0.8	—	0.6-0.8	—	—	HT......	1620-1710	1400-1435	—	Water	110	21	240	—
SAE 5120	0.17-0.22	—	0.7-0.9	—	0.7-0.9	—	—	HT......	1700	1420	—	Water	110	21	240	—
En 18[d]	0.35-0.45	—	0.6-0.95	—	0.85-1.15	—	—	HT......	—	1560-1620	1020-1290	Water or oil	100-123	18-22	200-300	1⅛-4
SAE 1540	0.38-0.43	—	0.7-0.9	—	0.7-0.9	—	—	HR......	—	—	—	—	114	20	223	—
								HT......	—	1550	1200 max	Oil	108-174	13-22	220-360	1-4
En 11	0.5 -0.7	—	0.5-0.8	—	0.5-0.8	—	—	HT......	—	1470-1560	930-1290	Oil	123-145	12-15	250-340	2½
SAE 5160	0.55-0.65	—	0.75-1.0	—	0.7-0.9	—	—	HT......	—	1540	1110 max	Oil	168	18	340	—
CHROMIUM-MOLYBDENUM STEELS																
En 19	0.35-0.45	—	0.5-0.8	—	0.9-1.5	0.2-0.4	—	HT......	—	1560-1600	1020-1320	Water or oil	100-157	15-22	201-375	1⅛-9
SAE 4140	0.38-0.43	—	0.75-1.0	—	0.8-1.1	0.15-0.25	—	HR......	—	—	—	—	134	20	269	—
								A........	—	—	—	—	100-114	15-25	210-240	—
								HT......	—	1545	1000	Oil	186	11	380	—
								HT......	—	1545	800	Oil	215	10	440	—
En 20	0.22-0.5	—	0.4-0.7	0.3 ma	0.5-1.5	0.4-1.0	—	HT......	—	1560-1650	1020-1320	Water or oil	123 min	17 min	241-331	2½
En 29[e] (see also En 40)	0.15-0.35	—	0.65 max	0.4 max	2.5-3.5	0.3-0.7	—	HT......	—	1630-1670	1390 max	Oil or air	224 min	10 min	444 min	2½
SPRING STEELS																
En 43[d]	0.45-0.60	0.10-0.40	0.6-0.8	—	—	—	—	—	—	—	—	Water	—	—	—	—
SAE 1050	0.48-0.55	0.10-0.30	0.6-0.9	—	—	—	—	—	—	—	—	Water	—	—	—	—
En 44[f]	0.90-1.20	0.30 max	0.45-0.7	—	—	—	—	—	—	—	—	Oil	—	—	—	—
SAE 1090	0.85-0.98	0.10-0.30	0.6-0.9	—	—	—	—	—	—	—	—	Oil	—	—	—	—
En 45	0.5-0.6	1.50-2.00	0.7-1.00	—	—	—	—	—	—	—	—	Oil	—	—	—	—
SAE 9255	0.5-0.6	1.80-2.20	0.7-0.95	—	—	—	—	—	—	—	—	Oil	—	—	—	—
En 45A	0.55-0.65	1.70-2.00	0.7-1.00	—	—	—	—	—	—	—	—	Oil	—	—	—	—
SAE 9260	0.55-0.65	1.80-2.20	0.7-1.00	—	—	—	—	—	—	—	—	Oil	—	—	—	—
En 46	0.35-0.45	1.5-2.0	0.7-1.00	—	—	—	—	—	—	—	—	Water	—	—	—	—
En 48	0.45-0.55	0.1-0.5	0.5-0.8	—	1.0-1.4	—	—	—	—	—	—	Oil	—	—	—	—
SAE 5152	0.48-0.55	0.1-0.3	0.7-0.9	—	0.9-1.2	—	—	—	—	—	—	Oil	—	—	—	—
En 47	0.45-0.55	0.5 max	0.5-0.8	—	0.8-1.2	—	0.15 min V	—	—	—	—	Oil	—	—	—	—
SAE 6150	0.48-0.53	0.1-0.3	0.7-0.9	—	0.8-1.1	—	0.15 min V	—	—	—	—	Oil	—	—	—	—
En 50	0.40-0.50	0.1-0.35	0.5-0.7	—	1.0-1.5	—	0.15 min V	—	—	—	—	Oil	—	—	—	—
SAE 6145	0.43-0.48	0.1-0.3	0.7-0.9	—	0.8-1.1	—	0.15 min V	—	—	—	—	Oil	—	—	—	—
En 48A	0.5-0.6	1.35-1.65	0.6-0.9	—	0.55-0.85	—	—	—	—	—	—	Oil	—	—	—	—
SAE 9262	0.55-0.65	1.8-2.2	0.75-1.00	—	0.25-0.40	—	—	—	—	—	—	Oil	—	—	—	—

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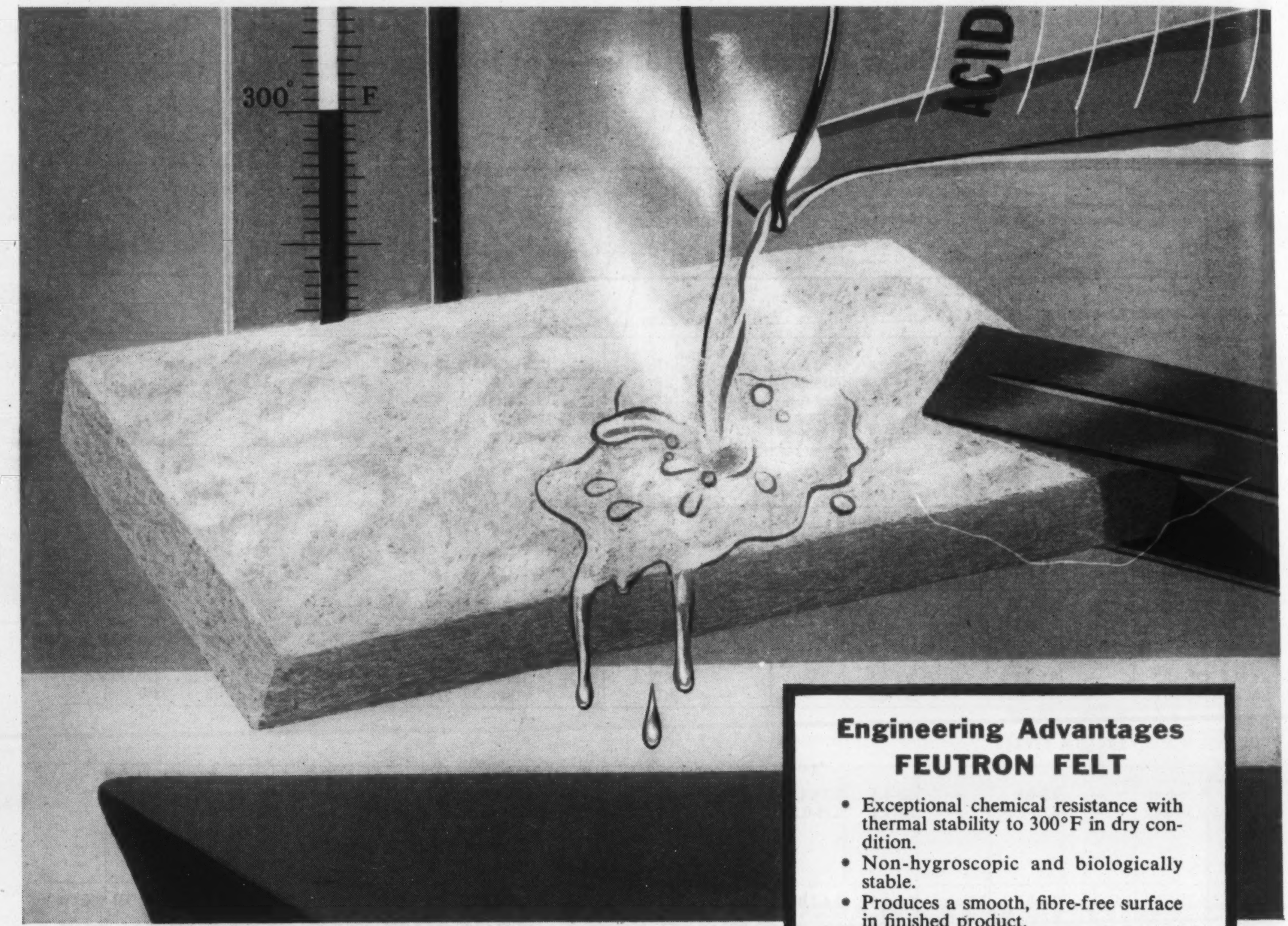
Feutron Felts

Withstand High Temperatures...Corrosive Conditions!



These are the toughest Felts you've ever seen!

FEUTRON Synthetic Felts possess the same chemical and heat-resistant properties as the fibers they are made from . . . Nylon, Orlon, Acrilan, Arnel, Dacron, Dynel, Vinyon . . . all the newest synthetics!

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A wide selection of FEUTRON styles and sizes . . . and precision-cut parts . . . are available. Mention the application in which you are interested . . . on your company letterhead, please . . . and we will send appropriate data sheet, complete with samples. And remember . . . quality

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American Felt Company
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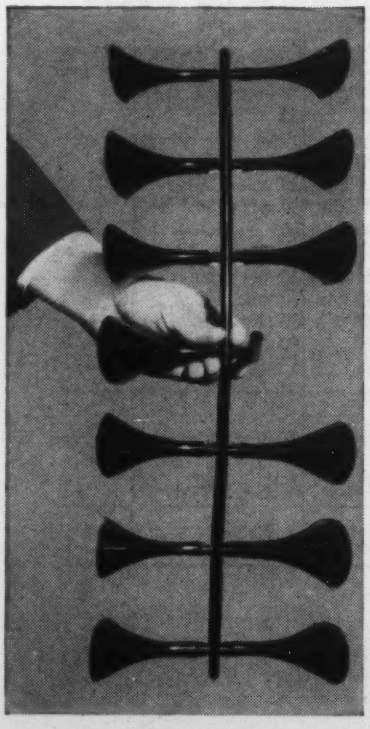
British and American Standard Steels—concluded

Designation	Composition, %							Heat Treatment, F			Mechanical Properties			
	C	Si	Mn	Ni	Cr	Mo	Other	Austenitize	Cool	Temper	Ten Str, 1000 psi	Elong, %	Brinell Hard-ness	Ruling, Section in.
CORROSION AND HEAT RESISTING STEELS														
En 56A	0.12 max	1.0 max	1.0 max	1.0 max	12.0-14.0	—	—	1740-1870	Oil or air	1380 max	80 min	25 min	150-200	6
BS1501-613	0.08 max	1.0 max	1.0 max	1.0 max	12.0-14.0	—	—	—	—	—	—	—	—	—
AISI 405	0.08 max	1.0 max	1.0 max	1.0 max	11.5-14.5	—	Al 0.1-0.3	—	—	—	75-85	20-30	185	—
En 56B	0.12-0.18	1.0 max	1.0 max	1.0 max	12.0-14.0	—	—	1740-1870	Oil or air	1380 max	100 min	20 min	200-250	6
En 56C	0.18-0.25	1.0 max	1.0 max	1.0 max	12.0-14.0	—	—	1740-1870	Oil or air	1380 max	112 min	16 min	225-280	4
En 56D	0.25-0.35	1.0 max	1.0 max	1.0 max	12.0-14.0	—	—	1740-1870	Oil or air	1380 max	168 min	8 min	340 min	1⅛
En 56AM	0.12 max	1.0 max	1.5 max	1.0 max	12.0-14.0	0.6 max	0.75 S, 0.6 Se, 0.6 Zr, 0.35 Pb[g]	1740-1870	Oil or air	1380 max	80 min	20 min	150-200	6
AISI 416Se	0.15 max	1.0 max	1.25 max	—	12.0-14.0	0.6 max	0.15 min Se	1800	Oil or air	600	180	13	375	1
En 56BM	0.12-0.18	1.0 max	1.5 max	1.0 max	12.0-14.0	0.6 max	Same as En 56 AM	1740-1870	Oil or air	1380 max	100 min	15 min	200-250	6
En 56CM	0.18-0.25	1.0 max	1.5 max	1.0 max	12.0-14.0	0.6 max	Same as En 56 AM	1740-1870	Oil or air	1380 max	112 min	12 min	225-280	4
En 56DM	0.25-0.35	1.0 max	1.5 max	1.0 max	12.0-14.0	0.6 max	Same as En 56 AM	1740-1870	Oil or air	1380 max	112 min	12 min	225-280	4
AISI 420F	0.15-0.45	1.0 max	1.0 max	—	12.0-14.0	—	0.18-0.35 Se	—	—	—	95	20	195	—
En 57	0.25 max	0.1-1.0	1.0 max	1.0-3.0	15.5-20.0	—	—	1740-1870	Oil or air	1020-1200	123 min	15 min	250 min	6
AISI 431	0.20 max	1.0 max	1.0 max	1.25-2.5	15.0-17.0	—	—	1800	Oil	1100	125	20	260	—
En 58A[h]	0.16 max	0.2 min	2.0 max	7.0-10.0	17.0-20.0	—	—	1740-2100	Air, oil or water	—	80 min	30 min	150	6
AISI 301	0.15 max	1.0 max	2.0 max	6.0-8.0	16.0-18.0	—	—	1900	Air, oil or water	—	85	50	150	—
AISI 302	0.15 max	1.0 max	2.0 max	8.0-10.0	17.0-19.0	—	—	1900	Air, oil or water	—	85	50	150	—
En 58B[i]	0.15 max	0.2 min	2.0 max	7.0-10.0	17.0-20.0	—	Ti>4xC	1740-2100	Air, oil or water	—	80 min	30 min	150	6
En 58C	0.15 max	0.2 min	2.0 max	9.0-12.0	17.0-20.0	—	Ti>4xC	1740-2100	Air, oil or water	—	80 min	30 min	150	6
AISI 81 321	0.08 max	1.0 max	2.0 max	9.0-12.0	17.0-19.0	—	Ti>5xC	1900	Air, oil or water	—	85	50	150	—
En 58E	0.08 max	0.2 min	2.0 max	8.0-11.0	17.5-20.0	—	—	1740-2100	Air, oil or water	—	80 min	30 min	150	6
AISI 304	0.08 max	1.0 max	2.0 max	8.0-12.0	18.0-20.0	—	—	1900	Air, oil or water	—	85	50	150	—
En 58F[t]	0.15 max	0.2 min	2.0 max	7.0-10.0	17.0-20.0	—	Cb>8xC	1740-2100	Air, oil or water	—	80 min	30 min	150	6
En 58G	0.15 max	0.2 min	2.0 max	9.0-12.0	17.0-20.0	—	Cb>8xC	1740-2100	Air, oil or water	—	80 min	30 min	150	6
BS1501-821B	0.10 max	0.2-1.0	2.0 max	8.0-12.0	17.0-19.0	—	Cb>10xC, 1.2 max	1740-2100	Air, oil or water	—	80 min	30 min	150	—
AISI 347	0.08 max	1.0 max	2.0 max	9.0-13.0	17.0-19.0	—	Cb+Ta, 10xC	1900	Air, oil or water	—	90	50	160	—
En 58H	0.12 max	0.2 min	2.0 max	8.0-12.0	17.0-20.0	1.5-2.5	Ti or Cb opt	1740-2100	Air, oil or water	—	80 min	30 min	150	6
En 58J	0.12 max	0.2 min	2.0 max	8.0-12.0	17.0-20.0	2.5-3.5	Ti or Cb opt	1740-2100	Air, oil or water	—	80 min	30 min	150	6
BS1501-845B	0.08 max	0.2-1.0	2.0 max	10.0 min	16.0-18.0	2.5-3.0	—	1740-2100	Air, oil or water	—	80 min	30 min	150	—
AISI 316	0.08 max	1.0 max	2.0 max	10.0-14.0	16.0-18.0	2.0-3.0	—	1950	Air, oil or water	—	80	50	150	—
AISI 317	0.08 max	1.0 max	2.0 max	11.0-15.0	18.0-20.0	3.0-4.0	—	2000	Air, oil or water	—	85	50	165	—
En 58D[j]	0.16 max	0.2 min	2.0 max	11.0-14.0	11.0-14.0	—	—	—	—	—	—	—	—	—
En 60	0.12 max	1.0 max	1.0 max	0.5 max	16.0-18.0	—	—	1290-1440	Air	—	—	—	—	—
AISI 430	0.12 max	1.0 max	1.0 max	—	14.0-18.0	—	—	1400-1525	Air or water	—	75	30	150	
En 61	0.12 max	1.0 max	1.0 max	0.5 max	20.0-22.0	—	—	1290-1440	Air	—	—	—	—	—
AISI 442	0.20 max	1.0 max	1.0 max	—	18.0-23.0	—	—	1400-1525	Air or water	—	75	30	160	—

Returns drop sharply when heels are made of Tenite plastics



Heels molded of Tenite Acetate or Tenite Butyrate have exceptional toughness and a strength far exceeding that of heels made of wood. One manufacturer reports he has not received a single breakage return from 250,000 pairs of shoes shipped during the seven months he's been using heels of Tenite plastic.

The superior toughness of the Tenite plastics virtually eliminates breakage during manufacturing, wear, or lift replacement. Moreover, these plastics facilitate an excellent finish. Heels can be used "as molded," sprayed with lacquer, metallized, or covered with plastic, leather or fabric. Lacquers and adhesives that work very satisfactorily with the Tenite materials are readily available.

Tenite plastics improve the performance of products in many different fields. For information on these versatile materials, write **EASTMAN CHEMICAL PRODUCTS, INC.**, subsidiary of Eastman Kodak Company, **KINGSPORT, TENNESSEE.**

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1932—EASTMAN'S 25TH YEAR IN PLASTICS—1957

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What's new IN MATERIALS

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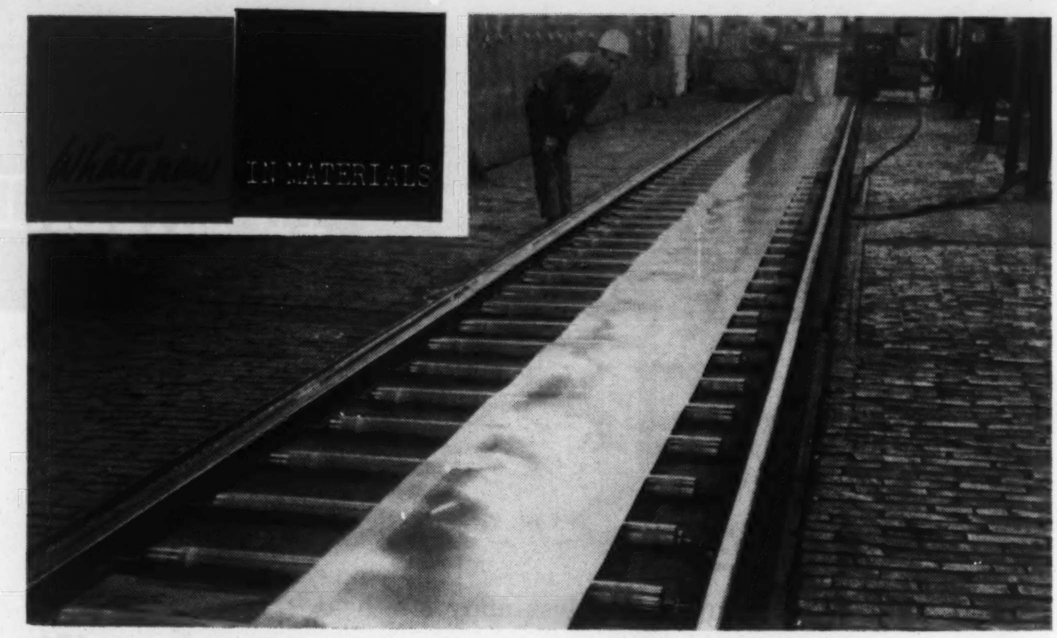
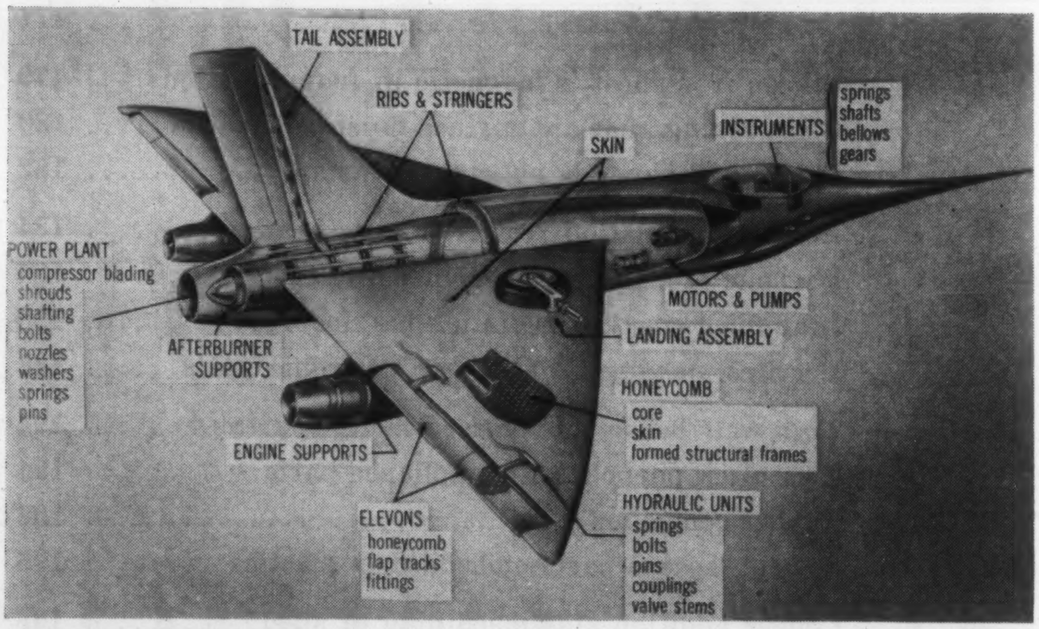

IN MATERIALS

New high strength steel *is produced in 36-in. wide sheet.*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valve stems

Extensive future use *of PH 15-7 Mo is forecast in artist's conception of future plane.*

High Strength Stainless Alloy Has Heat Resistance for Mach 4

■ An alloy that can withstand the high temperatures and stresses encountered at supersonic flight has been developed by Armco Steel Corp., Middletown, Ohio. The new metal, a precipitation hardening stainless steel designated PH 15-7 Mo, is claimed to be capable of being heat treated to strengths as high as 260,000 psi and to withstand the 1000 F heat created by air friction at 2700 mph.

Advantages

In addition to heat resistance and strength, the new stainless steel has several other outstanding features:

1. It is claimed to be the most easily fabricated high strength steel available for aircraft and missiles today and, because it can be easily brazed, it is potentially valuable for use in honeycomb sandwich construction.

2. It is claimed to be the only high strength, elevated temperature metal available commercially in the form of bars, billets, forgings, wire, sheet, strip, plate and foil. In addition, it can be made within thickness and flatness tolerances that are closer than normal.

3. It is said to cost only one-tenth as much as high strength titanium alloys.

Composition

The high strength properties of PH 15-7 Mo result from a strong precipitation hardening reaction which is fostered by the presence of about 1.2% aluminum (see Table 1). Additions of about 2.5% molybdenum insure retention of these properties even at temperatures as high as 1000 F. Although martensitic steels usually rely upon carbon for their high strength, the carbon in PH 15-7 Mo is controlled at low levels (below 0.09%) to permit welding without the preheating or post annealing treatments usually necessary to minimize cracking.

The new steel has a predominately austenitic grain structure in the soft annealed condition. As a result, it is claimed to be one of the easiest to cold form of all the high strength materials. Futhermore, the steel differs from ordinary high strength steels in that it does not temper nor deteriorate in room temperature strength as a result of exposure for long periods of time in the range of 400 to 800 F. In fact, a slight increase in room temperature strength has been measured after the precipitation hardened steel has been stressed above operating limit stresses for 1000 hr at 800 F.

Hardening

Procedures used for hardening this steel may vary. When severe cold forming is necessary, annealed sheet is used. If only mild forming operations are required, hard cold rolled sheet and strip may be used to provide exceptionally high strength with a simple 900 F heat treatment. In either case, a partially hardened or transformed state must exist before the precipitation hardening treatment is applied. The sequence of operations in fabricating and heat treating PH 15-7 Mo sheet and strip is shown in Table 2, along with typical room temperature properties for each condition.

Comparative properties of PH 15-7 Mo stainless alloy

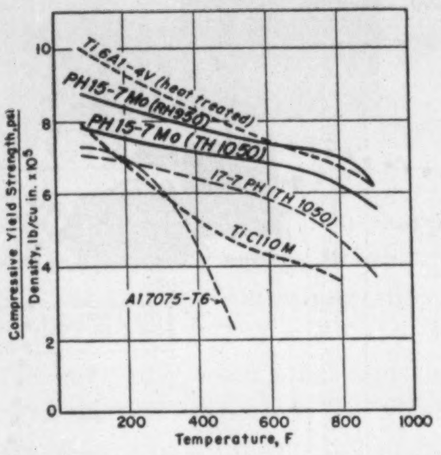


Fig 1—*Ratio of compressive yield strength to weight of PH 15-7 Mo compared with four other materials.*

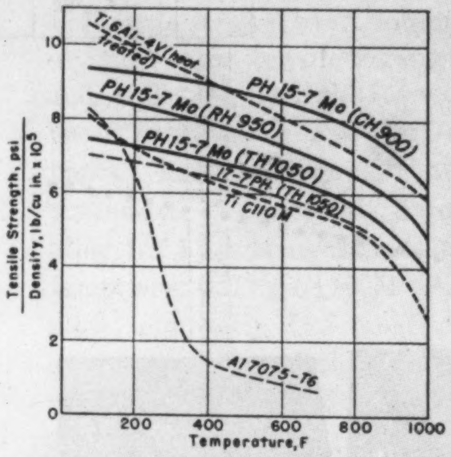


Fig 2—*Ratio of tensile strength to weight of PH 15-7 Mo compared with four other materials.*

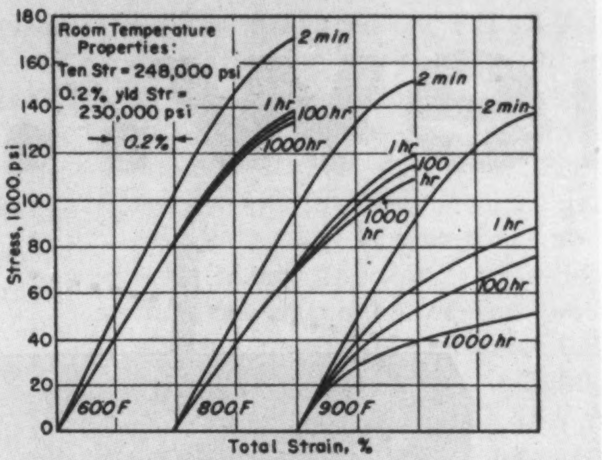


Fig 3 — *Tensile stress-strain-time curves for typical PH 15-7 Mo sheets.*

TABLE 1—
COMPOSITION OF PH 15-7 MO (%)

Chromium	15
Nickel	7
Aluminum	1.2
Molybdenum	2.5
Carbon	0.09 max

Since strength and ductility are influenced by the extent of the transformation of austenite to martensite and by the times and temperatures used for precipitation hardening, these properties may vary. If cold work alone is used to transform the austenite to martensite, strength will vary directly with the amount of cold work. If heat treatment is used to affect the transformation, the degree of carbide precipitation and the level of temperature to which the steel is cooled are the controlling variables. Optimum strengths are achieved by precipitation hardening at 950-1000 F for short times. For higher ductility, higher precipitation hardening temperatures are recommended. Guaranteed properties are given in Table 3.

Properties

Compressive yield strength—The ability of parts to be loaded in compression and still retain their original shape when unloaded is one of the most important design criteria for airframe

TABLE 2—TYPICAL ROOM TEMPERATURE PROPERTIES OF PH 15-7 MO SHEETS DURING FABRICATING AND HARDENING

Property ↓	Condition A (annealed sheet)		Condition C (hard rolled sheet)
Tensile Strength 1000 psi	130		220
Yield Strength (0.2% offset), 1000 psi	55		190
Elongation, %	30		5
	Heat Treatment After Forming[a]		Mild Forming
	Condition T Heat 1½ hr at 1400 F, cool 1 hr, hold ½ hr min at 60 F	Condition R-100 Heat 10 min at 1750 F, cool in air, refrigerate 8 hr at −100 F	Transformed by cold work ↓
Tensile Strength, 1000 psi	145	180	
Yield Strength (0.2% offset), 1000 psi	95	125	
Elongation, %	7	7	
	Precipitation Hardening[b]		
	Condition TH1050 Heat 1½ hr at 1050 F, air cool	Condition RH950 Heat 1 hr at 950 F, air cool	Condition CH900 Heat 1 hr at 900 F, air cool
Tensile Strength, 1000 psi	210	240	265
Yield Strength (0.2% offset), 1000 psi	200	215	260
Elongation, %	7	6	2

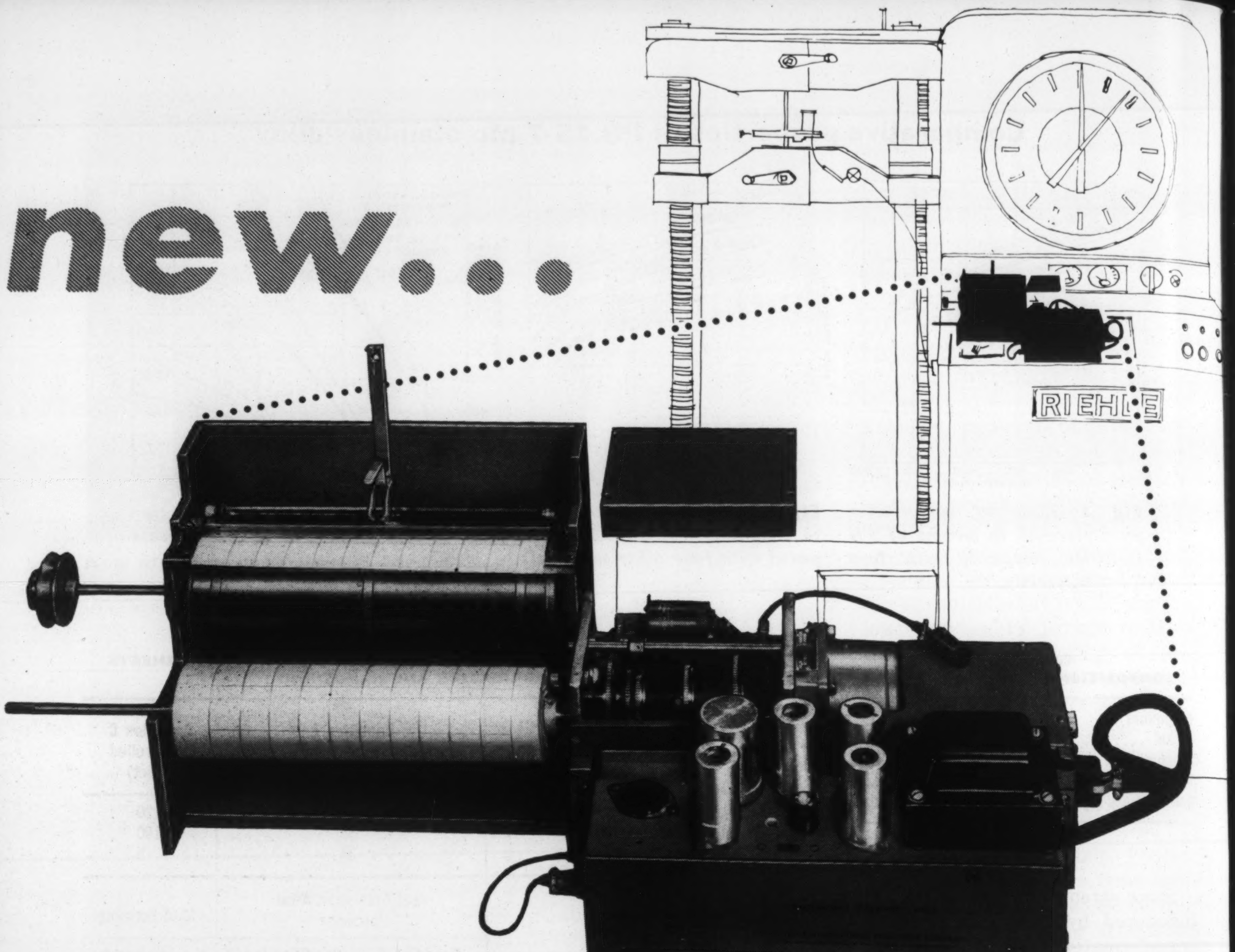
[a] Maximum expansion of 0.5% occurs with the change in phase.
[b] Contraction of about 0.04% results during precipitation hardening.

TABLE 3—GUARANTEED ROOM TEMPERATURE PROPERTIES OF PH 15-7 MO

Condition ➡	A	TH1050	RH950
Ten Str, 1000 psi	150 max	190 max	225 max
Yld Str (0.2% offset), 1000 psi	65 max	170 max	200 max
Elong (in 2 in.), %	25 min	5 min[a]	4 min[a]

[a] For 0.020-in. thickness and thicker.

new...



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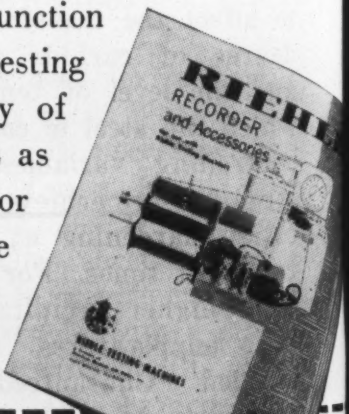

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parts. As shown in Fig 1, a sharp drop in strength occurs at about 250 F for the best aluminum alloy. And although 17-7PH and C110 M—the currently used steel and titanium alloys—approach the good performance of aluminum at ordinary temperatures, only the new PH 15-7 Mo steel or the 6Al-4V titanium alloy displays good performance at elevated temperatures.

Tensile strength—A comparison of short time tensile strengths of materials on a "weight for weight" basis is given in Fig 2. On this basis, the inadequacy of the strongest commercial aluminum alloy for high temperature service is apparent. The C110 M titanium alloy, currently the most readily available of the titanium alloys, is comparable to the 17-7 PH steel. However, at temperatures above 500 F, the tensile strength-weight ratios of PH 15-7 Mo steel are found to bracket those of the heat treated 6Al-4V titanium alloy.

Creep behavior — The total strains measured for PH 15-7 Mo sheets under varying conditions of tensile stress for periods ranging from 2 min to 1000 hr at 600-900 F are shown in Fig 3. As shown, the new steel is quite resistant to deformation under both short and long time loading. Measurement of the tensile stresses required to produce 0.2% permanent deformation in 1000 hr at 800 F show that PH 15-7 Mo is three times as strong under these conditions as the currently used 17-7PH.

Rubber-Like Adhesive Joins Polyethylene to Rubber, Brass

■ Polyethylene can now be joined directly to brass and brass plated metals and to natural and some synthetic rubbers with a new adhesive that is made of a synthetic material known as "partly hydrogenated polybutadiene." The adhesive, developed at Bell Laboratories, may also be used with plastics that are related to polyethylene.

With the adhesive it is possible to achieve peel strengths up to 100 lb per in. and tensile strengths of 1000 psi. These values are said to be considerably higher than values achieved with presently available adhesives.

Rubbers that can be joined directly to polyethylene include natural rubber, neoprene and butadiene-styrene synthetic rubbers. The new process requires only the adhesive to join rubber and polyethylene together. Previously, it was necessary to use four intermediate layers of polyethylene and natural rubber mixes.

Applications

The adhesive is recommended for bonding polyethylene linings and coatings to tanks and plating racks, and for bonding polyethylene insulation to electrical conductors. According to Bell Laboratories, the process will protect metals from corrosion, since the polyethylene can be fixed directly on the metal without the use of intermediate materials other than the adhesive.

How it works

It is believed that the bonding agent adheres to polyethylene because of its similar chemical structure and thermoplastic properties. The hydrogenated polybutadiene used to make the adhesive is known commercially as Hydropol and is manufactured by the Phillips Petroleum Co., Bartlesville, Okla. Various materials are added to the Hydropol to make it capable of vulcanization.

In all probability, the bond to vulcanizable rubber occurs because of the formation of sulfur crosslinks at the interface during vulcanization. According to Henry Peters, developer of the adhesive, any degree of unsaturation of the polybutadiene between 3 and 30% gives the best bonds.

***Sandwich construction** is joined together with new adhesive that is capable of resisting a pull of approximately 1000 psi.*

A layer of bonding agent 2 to 3 mils thick is recommended for proper adhesion. The adhesive may be made up in a solution and sprayed, brushed or dipped to provide the desired layer. An alternate method is to fabricate the adhesive into a thin sheet and insert the sheet between the materials to be bonded. Bonding is accomplished by heating at 250 to 350 F and applying pressures of 100 psi or less.

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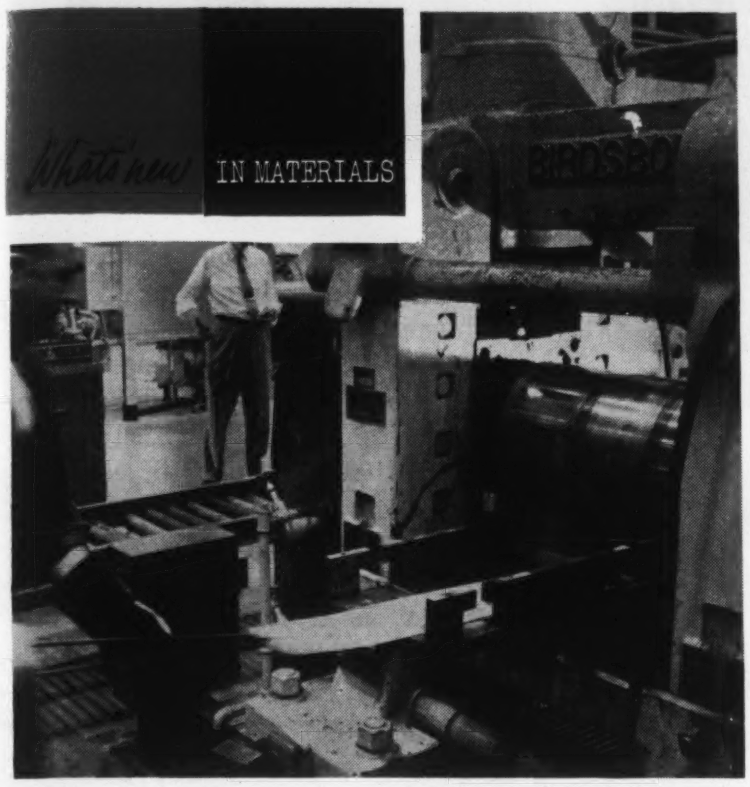
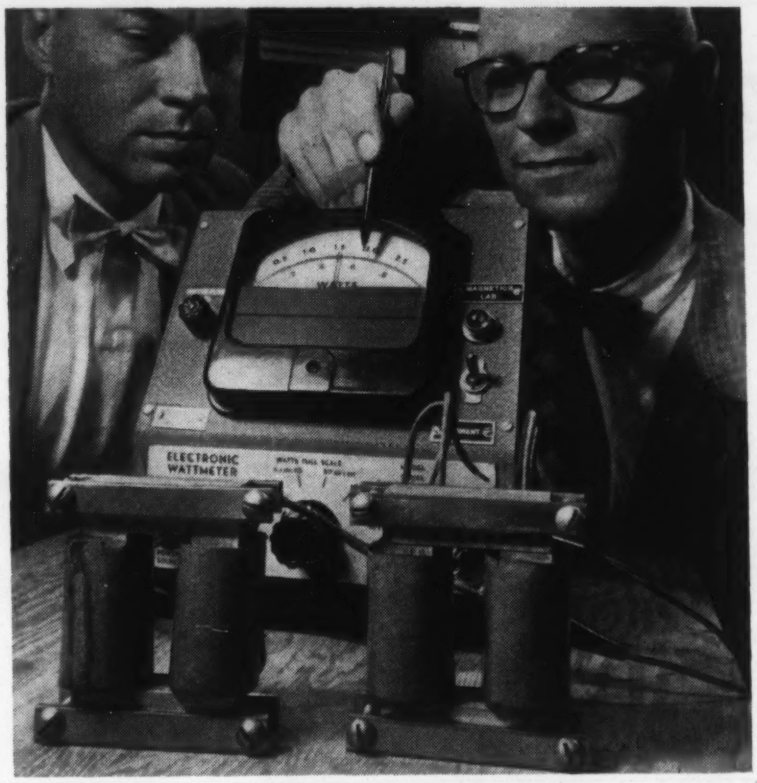


***Long sheets** of "four-square" silicon iron approximately 12 in. wide are produced in any desired thickness.*



***Transformer** containing new magnetic sheet (left) has lower energy loss (1.5) as indicated by needle, than ordinary transformer (right) as indicated by pen (2.0).*

Silicon Iron Sheet Is Magnetic in Four Directions

■ A new kind of magnetic sheet material, designed to increase the efficiency of transformers, motors and generators, has been developed at the General Electric Research Laboratory, Schenectady, N. Y. Called "four-square" silicon iron, the new doubly oriented magnetic sheet is easily magnetized in four directions and can be made in a wide range of useful thicknesses.

The magnetic sheet is currently in pilot plant production. GE officials believe that four-square sheet can eventually be made in production quantities at approximately the same cost as presently used magnetic sheet materials.

The basic raw material is a form of silicon iron similar in composition and cost to the typical "soft" magnetic sheet used in modern transformers and motors. Whereas "orientation" in silicon iron is achieved by aligning the individual crystalline grains in the finished sheet material, the doubly oriented four-square effect is produced by a different kind of alignment (technically referred to as "cube texture") which gives excellent magnetic properties not only back and forth *along* the sheet but also back and forth *across* the sheet.

Applications

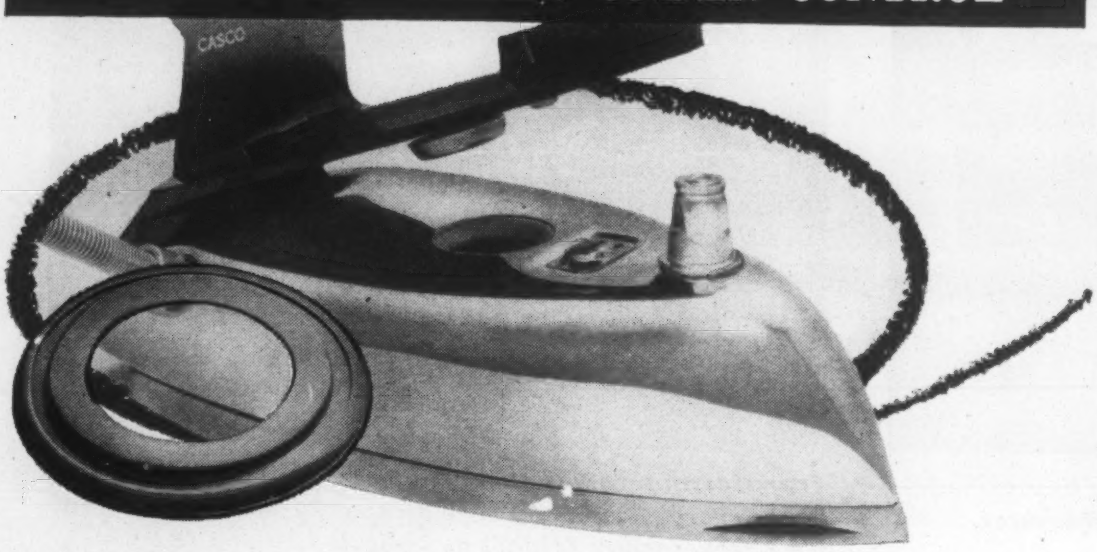
A typical application where the new magnetic sheet can be used most effectively is the iron core in a transformer. This core serves as a conductor of magnetic lines of force, guiding them from the primary winding coil to the secondary winding coil. When ordinary 60-cycle a.c. is used, the direction of magnetization changes 120 times every second. The core's resistance to these changes causes a loss of energy, reduced efficiency through the generation of heat, and mechanical vibrations which result in annoying "transformer noise." Since four-square silicon iron can be magnetized in four directions, its use as a transformer core should greatly lower energy losses and reduce noise in

Background of New Material

Ordinary iron was used in the earliest transformers, and the advantages of increasing efficiency by adding a small percentage of silicon were discovered near the turn of the century. In the 1930's scientists discovered that special rolling and heat treating techniques would produce sheets of singly oriented material that could be easily magnetized in two directions. By appropriately lining up the sheet in a transformer, generator or motor, most, but not all, of the magnetic flux could be carried in these two directions. Singly oriented magnetic sheets have reduced transformer core losses to a tenth of the loss experienced with the original unalloyed iron and a fifth of that characteristic of the original silicon-iron alloy. GE officials believe their four-square sheet promises "even further improvements in efficiency."

THE SHAPE OF THINGS IN MOLDED SILICONE

MOLDED SILICONE SEAL
KEEPS TAP WATER UNDER CONTROL



APPLICATION:
Funnel seal for steam and dry iron.

PROBLEM:
When this part was originally designed, Silicone rubber compounds with low shrinkage characteristics were not available. This resulted in a twofold problem; first, to produce a compound that would have excellent resistance to all types of tap water and would retain its sealing properties even if the iron were inadvertently run dry; secondly, to construct or match tooling to the characteristics of the compound.

SOLUTION:
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much electrical equipment.

In one familiar type of transformer core construction, the advantages of singly oriented materials can be realized on three sides of the square; even with this configuration there is still considerable loss at the corners. With four-square magnetic sheet, a variety of transformer core construction arrangements are possible which take advantage of the easy magnetization on all four sides. The new material also gives a substantial reduction in corner losses.

Westinghouse, Too

As this issue went to press, Westinghouse Electric Corp. announced its own development of doubly oriented silicon steel—a material apparently similar to that described here. Further details will appear in next month's issue.

How it's made

The key to successful production of the sheet is rigid control of the internal structure of the metal during all steps of processing, from the original casting through successive heat-treating and rolling mill operations. Processing steps follow the same general pattern as used in making singly-oriented materials. These steps begin by melting the raw material in a standard furnace. Subsequent rolling and heat treating of the cast ingots produces long sheets of material about 12 in. wide in any thickness.

Glass Roving, Mat Aid Surface Finish

Two new glass reinforcing agents for plastics, a glass roving and a glass mat, are said to have better fiber wet-out and bonding properties than presently avail-

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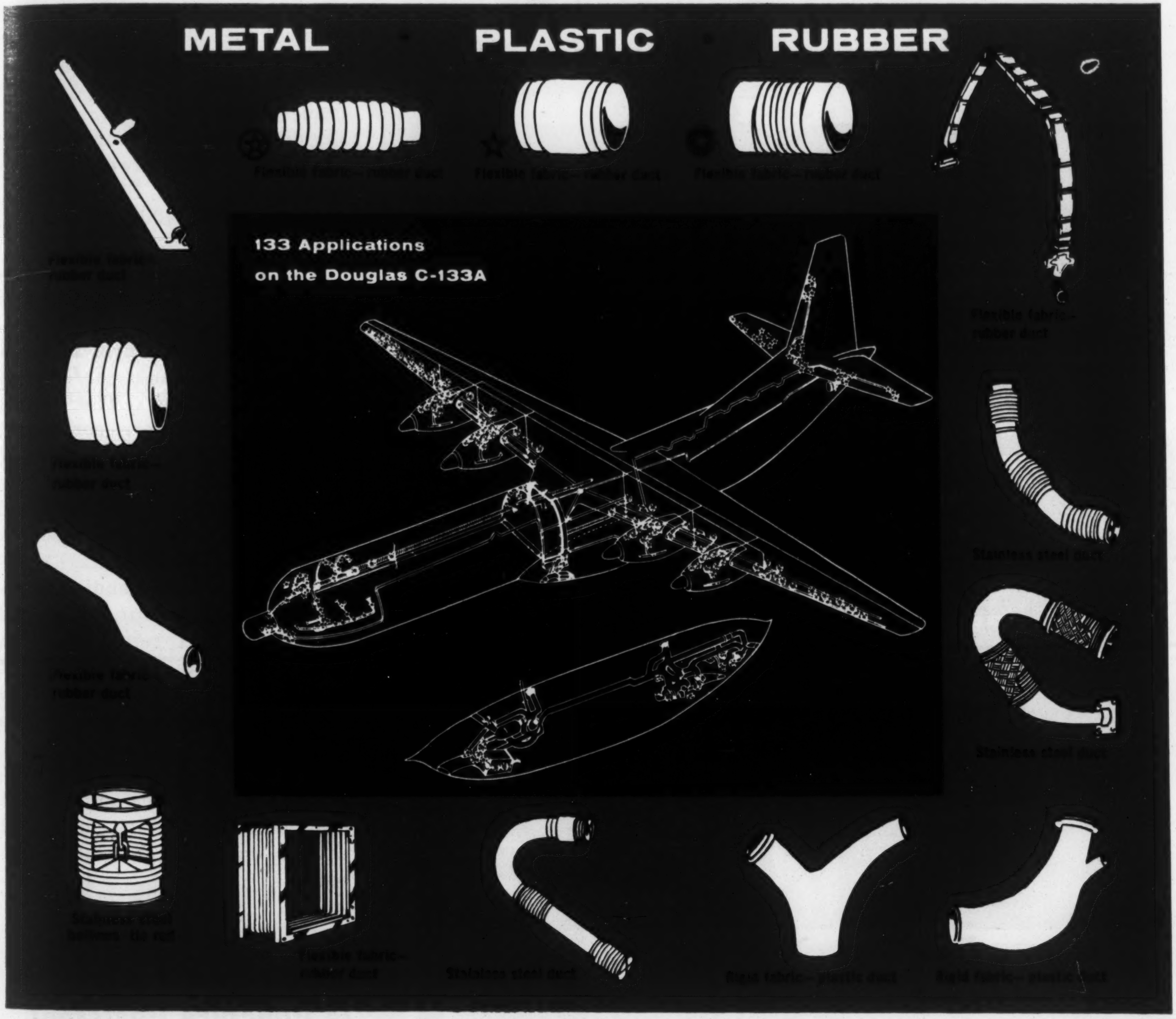

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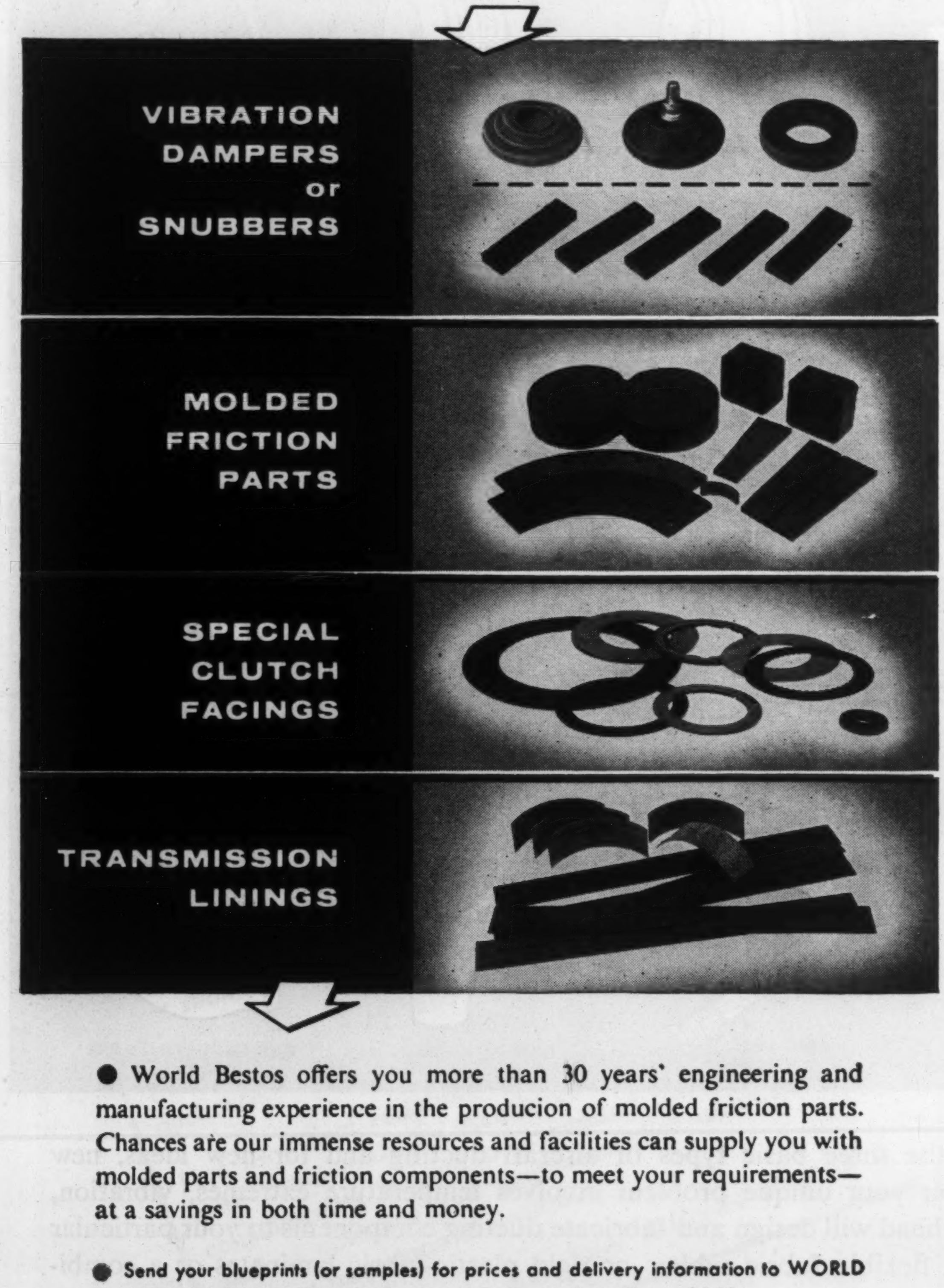

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able glass reinforcing agents. The products are also said to greatly improve the surface finish of glass reinforced plastics. First in a new line of glass reinforcing agents trade named "Super-Fi," the two products are now commercially available from Owens-Corning Fiberglas Corp., Plastics Div., 1834 Nicholas Bldg., Toledo 1, Ohio.

The glass roving, called Super-Fi R-600, is particularly adaptable to preform molding of such reinforced plastics products as appliance parts, housings, automotive parts and luggage. The roving, when used to reinforce corrugated sheets, is said to provide a sheet having a smoother surface, less resin richness and increased weatherability compared to sheets reinforced with other glass materials. Only a light sanding is required before painting a molded plastics product reinforced with the glass roving; previously it was necessary to subject a molded piece to several sandings before painting.

The other glass product, Super-Fi M-506, is a fine strand mat designed for use in corrugated sheets, containers and automotive parts.

Reinforced Paper Is Puncture Resistant

A reinforced paper, said to have good puncture resistant properties, has recently been introduced by Mosinee Paper Mills Co., Mosinee, Wis. According to the producer, a reinforcing agent of either rayon or fiberglass is incorporated into the sheet on the paper machines. The reinforcement is said to stop tearing of the paper if it is ruptured; in addition, the reinforcement is said to add strength to the paper in all directions.

Called Scrimtex, the paper is

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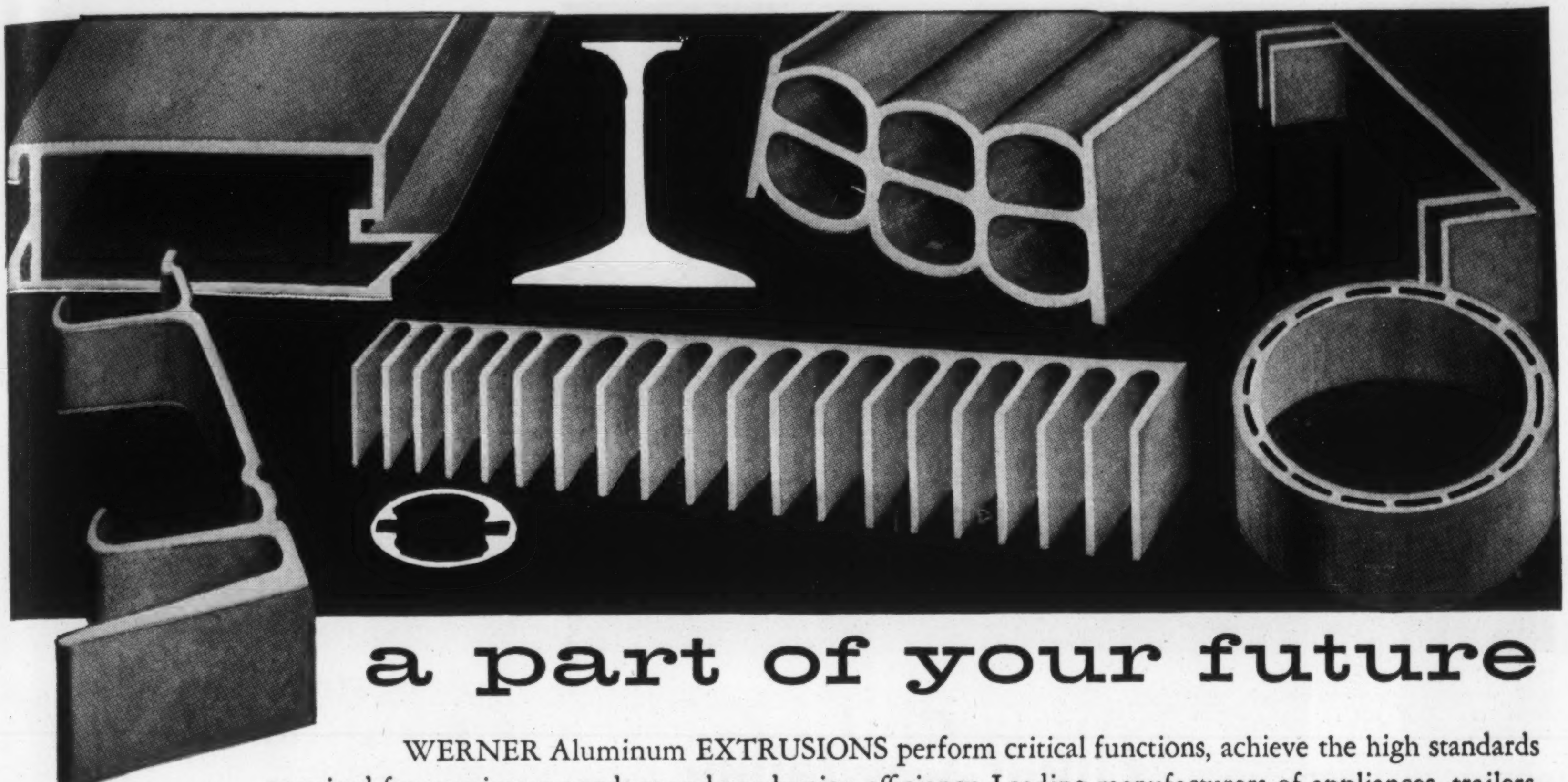

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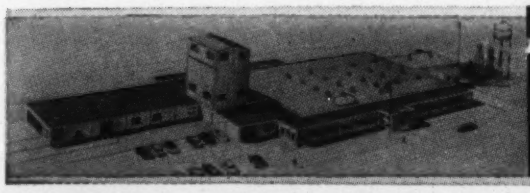

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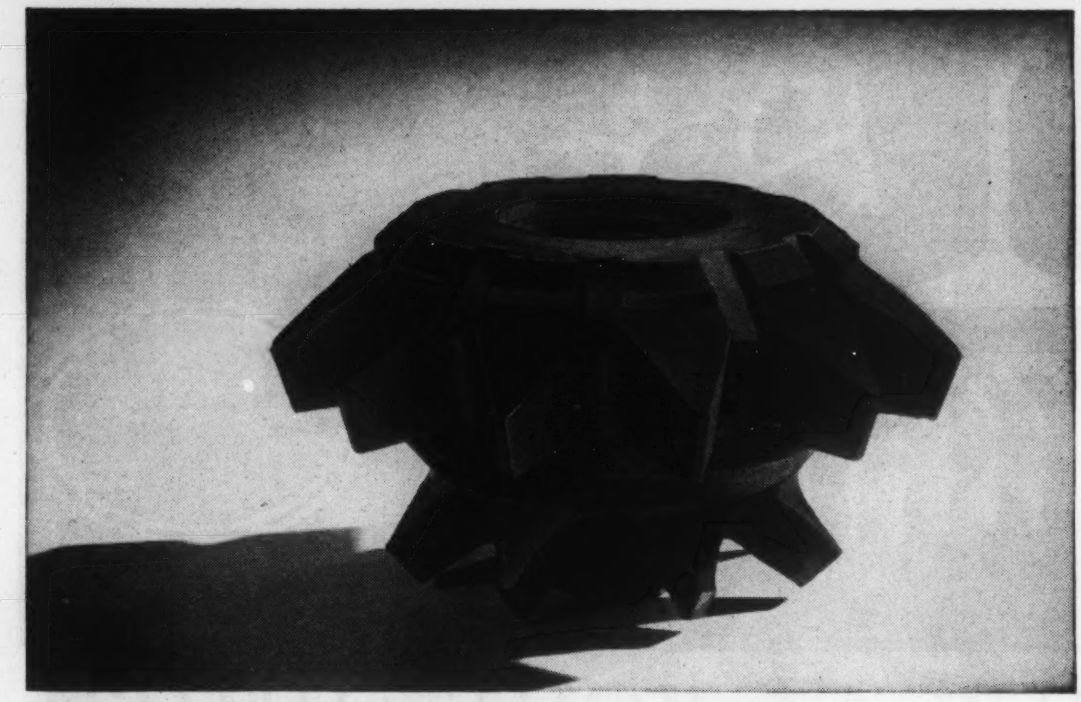
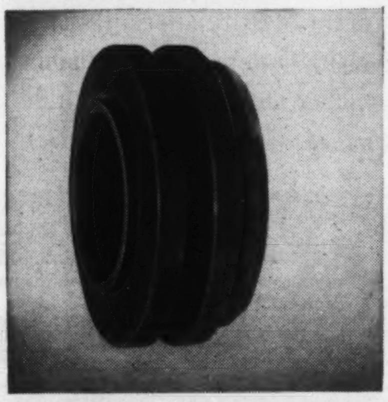


Oil well drill bit, carbide-surfaced by ASC, outlasts 5 untreated bits . . . cuts downtime 50% for oil exploration company.



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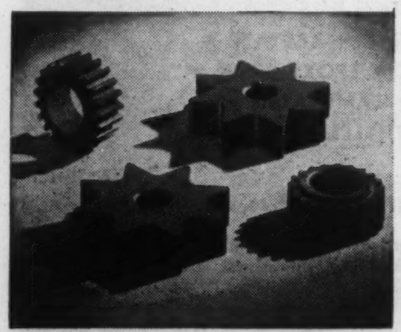

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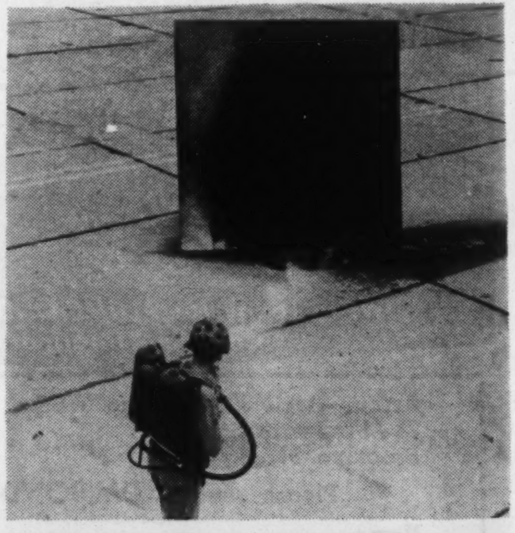
said to remain relatively strong and flexible at temperatures as low as –75 F. It has been used to package molten resins at temperatures as high as 425 F. The reinforced paper is suitable for use in shrouds, bags, temporary barriers, tents and awnings.

Asbestos Insulation Resists Intense Heat

A new, lightweight and completely incombustible insulating board called Asbestolux is being marketed for the first time in this country, according to North American Asbestos Corp., Board of

Flame's on: *Asbestos board is subjected to the full blast of a Marine Corps flamethrower.*



Flame's off: *Smudged by smoke, board is unaffected by intense heat from flamethrower.*

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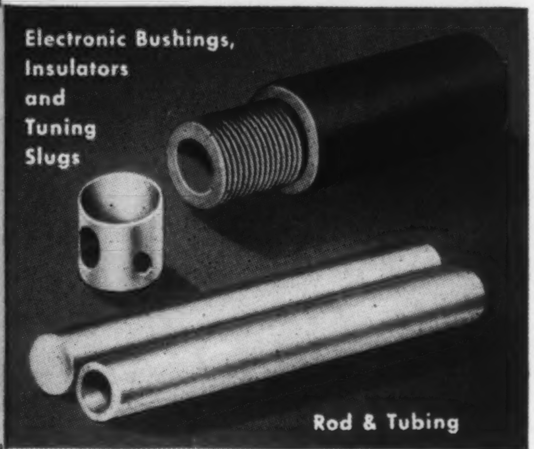
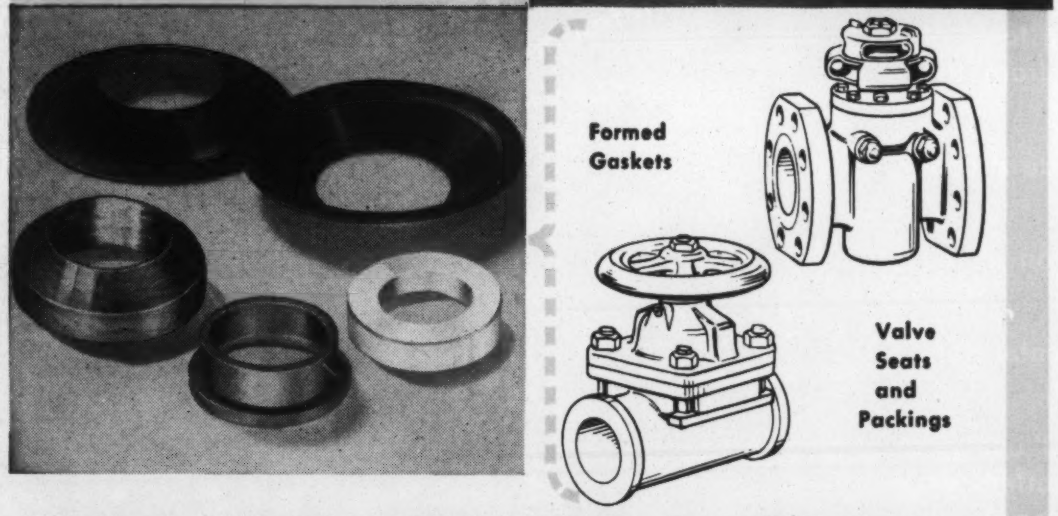




It has been definitely established that the value of Teflon can be considerably enhanced by the use of fillers in certain applications. Laboratory and field experience has demonstrated that the use of fillers permit Teflon to be more readily tailored to a wide variety of chemical, electrical and mechanical applications. Also, some mechanical properties can be improved. These include:

1) resistance to deformation under load
2) resistance to wear
3) thermal conductivity
4) compressive strength
5) hardness

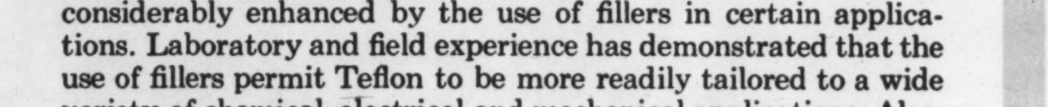
By thus improving its properties, Teflon now offers even greater industrial potential. This is the reason filled Teflon has become an important item in the "John Crane" Chemlon® line of better Teflon products.

Chemlon is available with such fillers as glass fiber, carbon, graphite, copper and bronze, talc, calcium fluoride and other inorganic materials.

SEE US AT THE DESIGN ENGINEERING SHOW
BOOTH 1042

Crane Packing Company, 6460 Oakton Street, Morton Grove, Illinois, (Chicago Suburb). In Canada: Crane Packing Co., Ltd., Hamilton, Ont

**DuPont Trademark*



CRANE PACKING COMPANY

For more information, turn to Reader Service card, circle No. 412

Trade Bldg., 141 W. Jackson St., Chicago 3, Ill.

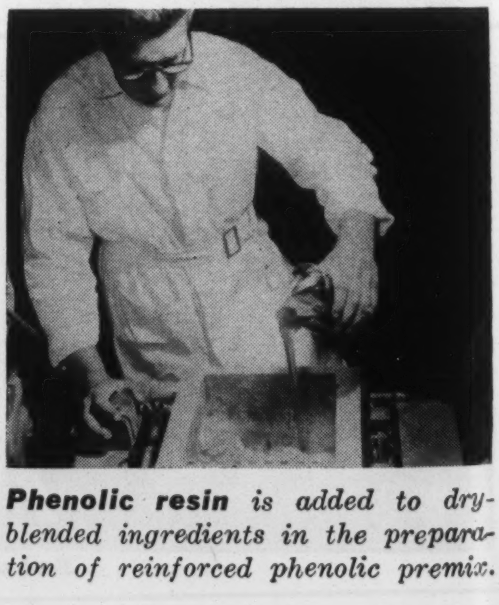
The material is made by bonding long asbestos fibers with a special silica in high pressure steam. The resiliency, strength and length of the fibers are said to contribute to its lightness (about the weight of plywood) and good workability. According to the producer, the material can be sawed, nailed and fastened with screws as easily as wood.

Since the new insulating board is made entirely of inorganic materials, it is said to be resistant to fire, heat, rot, mold and vermin. It is recommended as a thermal barrier for processes involving intense heat, and as an insulating material for electrical equipment.

Phenolic Premix May Lower Molding Costs

Should a plastics molder mix his own molding materials or buy "premixed" plastics molding compounds?

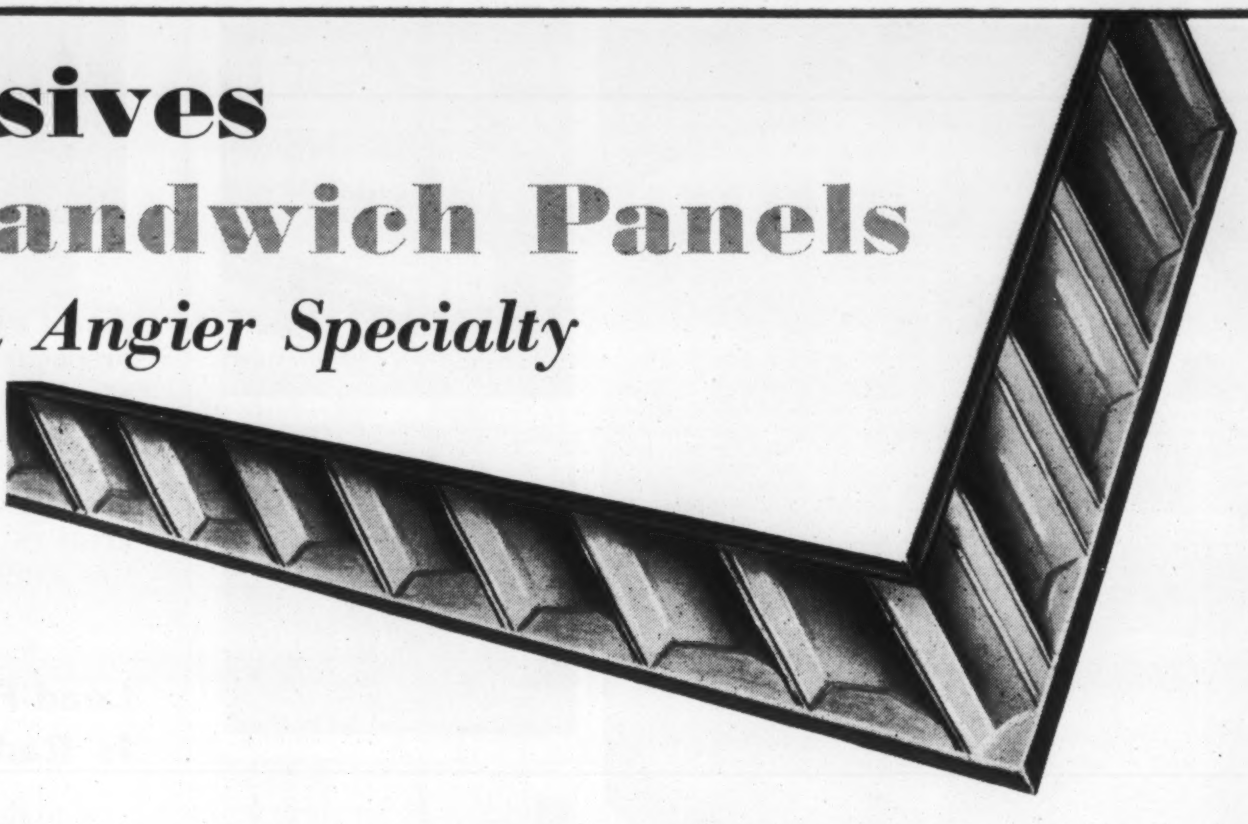
This controversy has now been extended to the phenolics with the introduction by Barrett Div., Allied Chemical & Dye Corp., 40 Rector St., New York 6, of a liquid phenolic which the end-user can "premix" prior to molding. The main objective seems to be cost savings, since there are no ap-

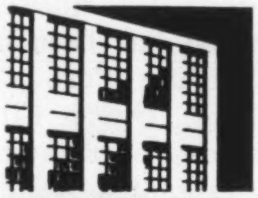


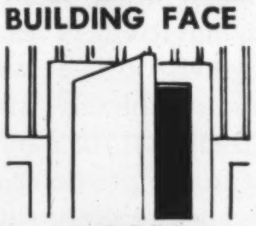
Phenolic resin *is added to dry-blended ingredients in the preparation of reinforced phenolic premix.*

Adhesives for Sandwich Panels

are an Angier Specialty







PARTITIONS

The end use of your sandwich panel fabrication may be for curtain walls for buildings, doors, partitions or aircraft. In each case, adhesive requirements will vary according to facings and cores used and the ultimate use planned for the panels.

Because of these wide variations in requirements, adhesives for sandwich panels are truly a specialty . . . and a specialty which Angier is highly qualified to represent as a result of long experience and research.

Sandwich panels now constructed with Angier adhesives include such facing materials as stainless steel, porcelain enameled steel and aluminum, hardboard, fibreboard, glass and paper. Some of the core materials are wood, honeycombs of paper, aluminum etc. and a variety of foam substances.

FOR MORE INFORMATION

Write on your company letterhead for data on our 5750 series (elastomeric type) for rigid laminating and sandwich panel construction as well as on the vinyl phenolic and epoxy types for Sandwich Panel work.

ANGIER ADHESIVES

For EVERY Industry

Latest developments in adhesives for Mylar* Lamination, Vinyl Film Bonding, also Rubber Latex and Resin Cements, Pressure Sensitive Cements, Flocking Cement, Laminants, Sealants, Tie Coats and Resin Emulsions.

***MYLAR is DuPont's registered trademark for its brand of polyester film.**

Angier Adhesives

Division of Interchemical Corporation

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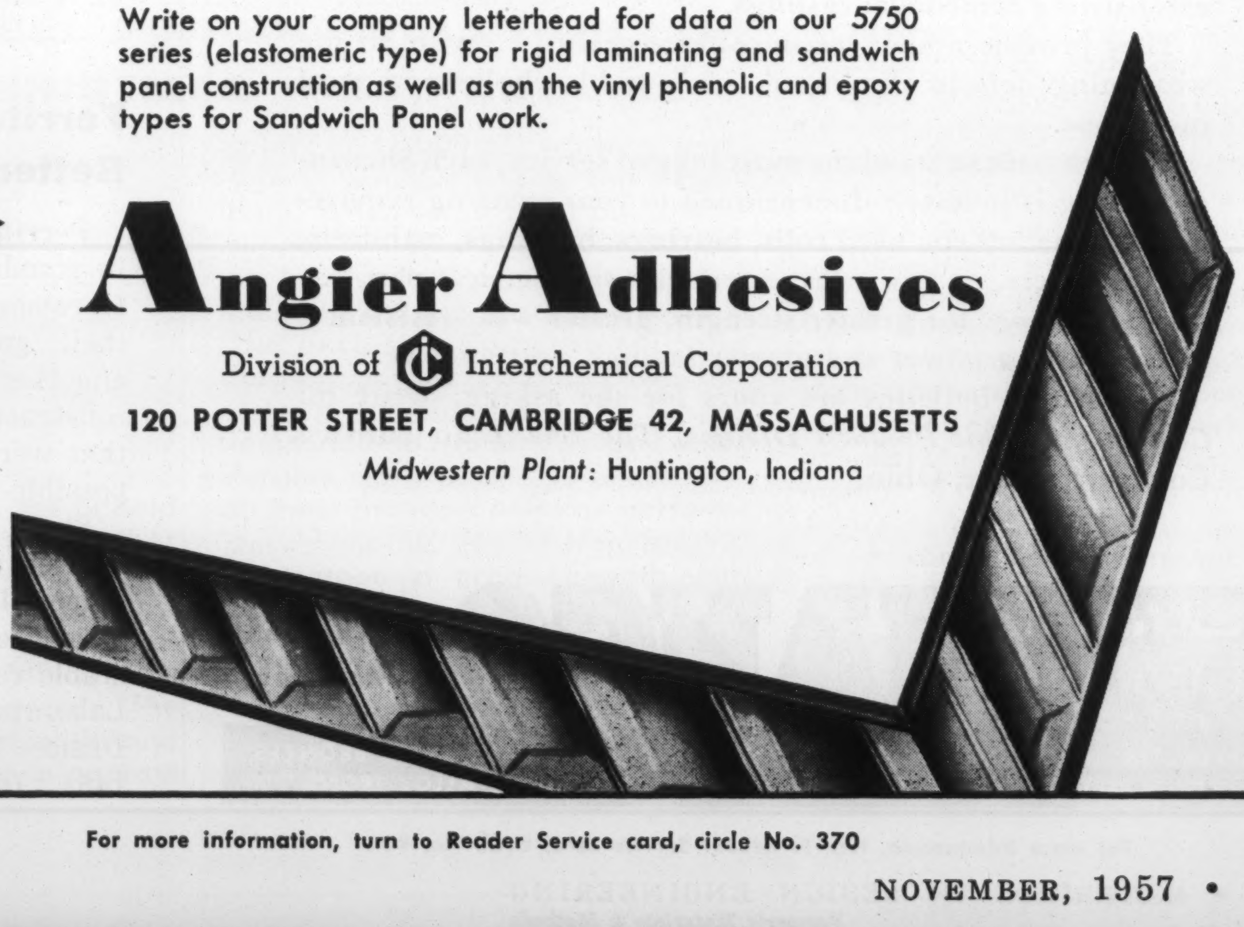
Midwestern Plant: Huntington, Indiana



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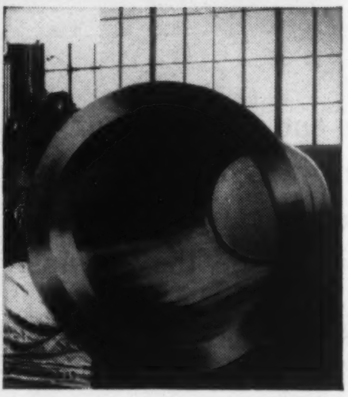

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They provide a finer, *pressure-dense* grain . . . with all the weakening defects eliminated, such as blowholes and sand inclusions.

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COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

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parent gains in product design or properties. Barrett says, "Molders of phenolics can save from 5 to 10¢ per lb by mixing their own impact materials." Actual cost reductions, of course, depend to a great extent on the mixing facilities available.

Lead-Filled Epoxy Is Radiation Barrier

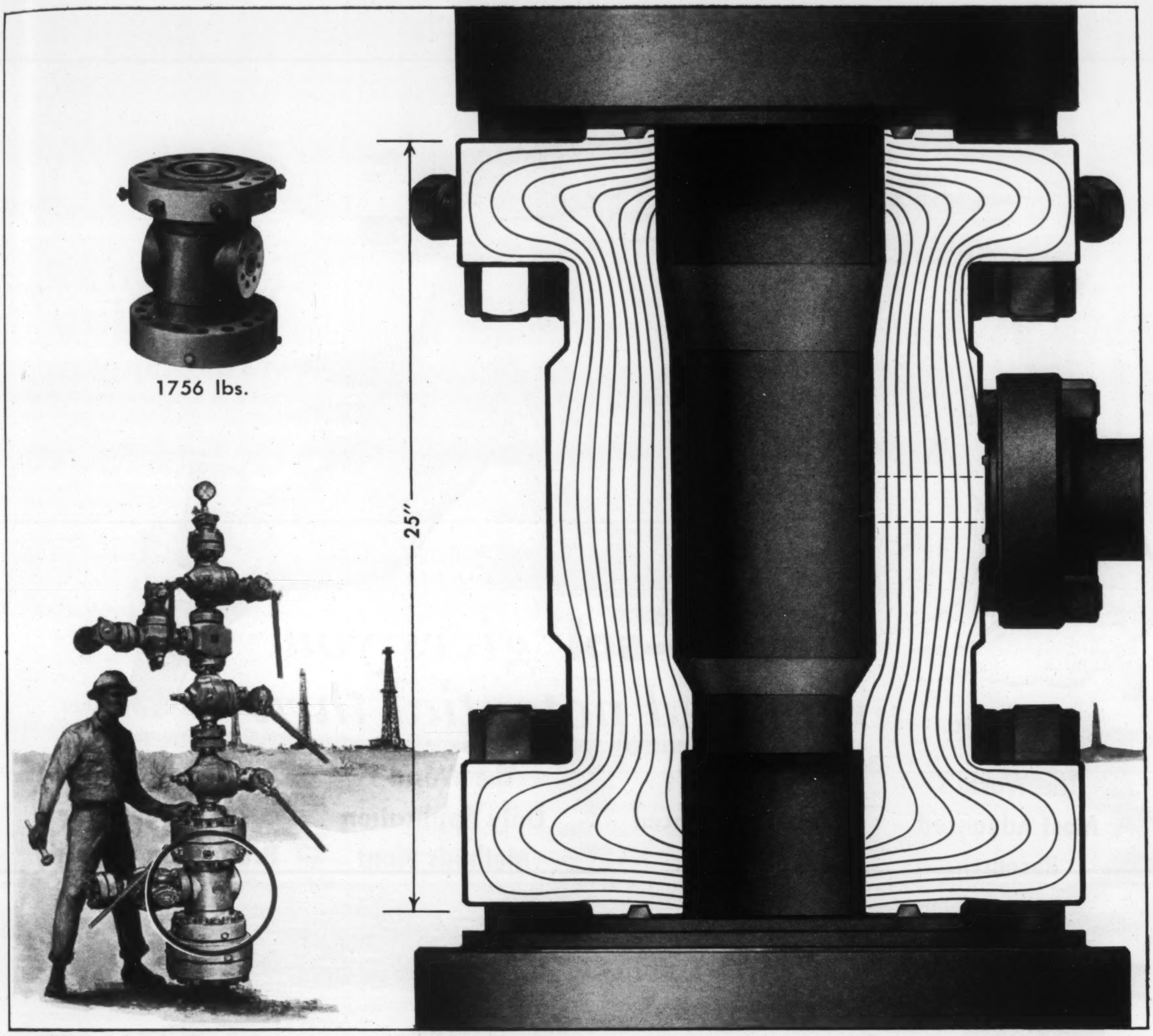
A high density, lead-filled epoxy casting material has been developed by Marblette Corp., 37-31 30th St., Long Island City 1, N. Y., for use as a barrier against radiation. Designated Resin No. 341, the formulation is easy to pour and, when mixed with a catalyst, sets completely after a brief room temperature cure.

According to the producer, castings made from the resin containing 95% lead by weight have greater hardness and rigidity than pure lead. The epoxy-lead castings are also said to be resisttant to oxidation, corrosion and contamination by most chemicals. The material is furnished in various lead loadings up to 95% lead by weight.

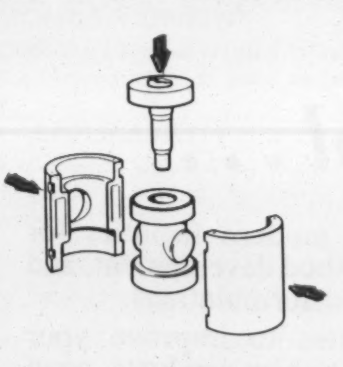
Ferrites Make Possible Better Electronic Parts

Ferrites are often better to use in standard electronic parts than ferromagnetic metals because of their good electrical properties, and they have made possible the construction of electronic devices that were previously thought impossible to make.

Since ferrites are finding increased use in a number of communication equipment parts, they have been the subject of considerable research at Bell Telephone Laboratories (see MATERIALS IN DESIGN ENGINEERING, Aug '57, p 145). In order to gain more in-



SPLIT-DIE STEEL FORGING SOLUTION FOR 15,000 PSI CHRISTMAS TREE PROBLEM



This tubing head spool for oilfield Christmas Trees is still another example of the superiority of Cameron's split-die steel forgings. Thousands of these critical components are on the job almost everywhere oil is produced. The model above must first withstand 22,500 psi test pressure to operate safely at 15,000 psi working pressure — but this is only the beginning. When set, it must be able to support in excess of 300,000 lbs. of heavy steel tubing suspended miles below the earth's surface.

The exclusive Cameron split-die forging process produces two important advantages — 1) Shapes impossible to produce by any other forging method, and 2) Grain flow to meet the most extreme performance demands. The inherent forging advantage of great strength with less mass has been extended to include a new design range. Open center sections, curved or flat surfaces in almost endless variety and odd protrusions are routine design elements when Cameron split-die forgings are specified. These vastly superior ferrous parts are forged to 8,000 lbs. weight.

Cameron is busy today producing split-die forged steel parts for jet engines, guided missiles, atomic reactors and, of course, Cameron Christmas Trees.

Our complete production facilities, from melting of high quality alloy steels to finished machining if desired, allows undivided responsibility — that's another reason why we are serving more customers every month. If you are using castings where forging quality is desired, or if conventional forgings are inadequate, write, call or come by—

Cameron
IRON WORKS, Inc.
P. O. Box 1212, Houston, Texas
SPECIAL PRODUCTS DEPARTMENT

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Chem-o-sol is our trade name for specially formulated polyvinyl dispersions (plastisols), which free the designer from the limitations of conventional materials. Inherently versatile because of their "liquid solid" nature, these dispersions offer unlimited opportunity to solve old problems and to develop new products, new forms, new characteristics. They are simple to apply, whether adapted as coatings and finishes or as shaped components.

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See opposite page for technical data

For more information, turn to Reader Service card, circle No. 461

formation on the electrical properties of both ferrites and ferromagnetic metals, J. K. Galt has investigated the dc and ac magnetic properties of these two types of materials. A discussion of his findings may be found in the Apr '57 issue of *Bell Laboratories Record.*

Comparison of materials

The ferrites are a class of ceramic magnetic materials formed by causing mixtures of various metallic oxides to react in the solid state at high temperatures. Electrically, their properties are broadly similar to those of semiconductors like silicon and germanium, but their magnetic properties are similar in many ways to those of iron, cobalt, nickel and other ferromagnetic metals.

Mr. Galt finds that the dc magnetic properties of the ferrites and the ferromagnetic metals are broadly comparable. However, he notes that the ac characteristics of the two groups of materials are very different because of their different electrical properties, particularly resistivity.

When induction is changed quickly in magnetic materials, either in magnitude or in direction, the speed of the change is limited by energy-loss mechanisms that tend to slow down the change. Induction changes in ferromagnetic metals are slowed down by "eddy currents" that are induced in a sample by any change in induction. On the other hand, ferrites have practically no energy-losses because their electrical resistivity is so many orders of magnitude higher than that of ferromagnetic metals. As a result, ferrites are useful at much higher frequencies than ferromagnetic metals, in such parts as transformers and induction coils.

Mr. Galt notes that ferrites and ferromagnetic metals have similar Curie points. Curie point is the temperature above which a

chem-o-sol® unlimited

TECHNICAL DATA

Chem-o-sol is supplied as a liquid and when fused at temperatures in the vicinity of 350°F. (some lower fusing compounds are available) results in a tough, resilient solid with all the outstanding physical and chemical properties associated with the polyvinyl chloride resins on which Chem-o-sol is based. Listed below are some of the properties which are available in Chem-o-sol in almost any combination:

COLOR
Available in any desired color.

TENSILE STRENGTH
As required within the range 1,000 psi. to 2700 psi.*

PERCENT ELONGATION
350 to 600*

HARDNESS (Shore A.)
As required within the range 10 to 100.

FLEXIBILITY
A fused section of Chem-o-sol is flexible at temperatures as low as —65°F.

CHEMICAL RESISTANCE
Highly resistant to most acids, alkalies, detergents, and to a wide range of oils and solvents.

HEAT RESISTANCE
Equivalent to other versions of vinyl based compounds. Chem-o-sol, with resistance to temperature of 225°F. for as long as 2000 hours and to temperature of 450°F. for over two hours is available.

DIELECTRIC STRENGTH
Minimum of 400 volts per mil when fused in sections 3 mils thick and over.

SOLIDS CONTENT
100% — Chem-o-sol can be molded in very thick sections. Reproduction of mold surface is excellent.

APPLICABILITY
Chem-o-sol is readily applied by dipping, die wiping, molding, casting, spraying, or spreader coating.

VISCOSITY
As required for application method.

*As measured by Model IP-4 Scott Tester.

Send For Chem-o-sol Brochure
When writing to us, use Page 10 of your chem-o-sol brochure as a guide to outline your project or new end use for Chem-o-sol. As soon as we know your requirements, our entire resources will be put to work.

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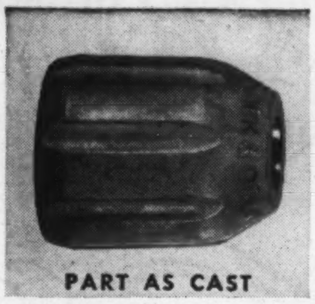
now you can get this brilliant finish directly on zinc die castings!

No electroplating--no mechanical finishing!



PART AS CAST

TREATED WITH NEW IRIDITE

NEW IRIDITE® (Cast-Zinc-Brite)

brightens zinc die castings by chemical polishing, protects against corrosion

NOW, FOR THE FIRST TIME you can get a brilliant, decorative finish directly on zinc die-cast parts . . . without mechanical finishing, without electroplating! The luster is provided by the *chemical polishing* action of new Iridite (Cast-Zinc-Brite) solution. Even surface blemishes, such as cold shuts, are brightened by this new process. No electrolysis. No special equipment. No specially trained personnel. Just a simple chemical dip for a few seconds and the job is done. And, this new Iridite has been *tested and proved* in production.

CORROSION RESISTANCE, TOO! New Iridite (Cast-Zinc-Brite) provides exceptional corrosion resistance for bright-type chromate finishes . . . also guards against blueing or darkening by eliminating zinc plate formerly required in bright chromate finishing of zinc die castings.

AS A BASE FOR ELECTROPLATING—Lower mechanical finishing costs are possible where plated finishes are *required* since the brightness provided by this new Iridite may be sufficient.

LET US SHOW YOU what Iridite (Cast-Zinc-Brite) can do for you. Send us at least a half-dozen typical zinc die-cast parts for FREE PROCESSING for your own tests and evaluation. Or, for immediate information, call in your Iridite Field Engineer. He's listed under "Plating Supplies" in your classified 'phone book. *IMPORTANT: when you give us samples for test processing, please be sure to identify the alloy used.*

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Manufacturers of Iridite Finishes for Corrosion Protection and Paint Systems on Non-Ferrous Metals; ARP Plating Chemicals

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material is no longer ferromagnetic and where the saturation induction drops sharply to values near zero. Typical Curie points for ferrites range from 200 to 1100 F. Crystalline magnetic anisotropy and magnetostriction values for the two groups of materials are also similar.

Magnetostriction, or strain that occurs in a magnetic material when the induction changes, is of interest for transducers that transform electromagnetic energy into mechanical energy. Cobalt ferrite is an example of a ferrite with an extremely large magnetostriction. Under suitable conditions, the dimensions of cobalt ferrite samples can be changed by as much as 0.08% with changes in its induction.

Chemically, the ferrites are metal oxide compounds. Their basic chemical formula may be written MFe_2O_4, where "M" represents a divalent metal ion (valence of ± 2) and the two iron ions are trivalent (valence of ± 3). Others of the "M" or divalent ions used to make different ferrites include nickel, cobalt, manganese, magnesium, mixtures of zinc and manganese, and mixtures of zinc and nickel.

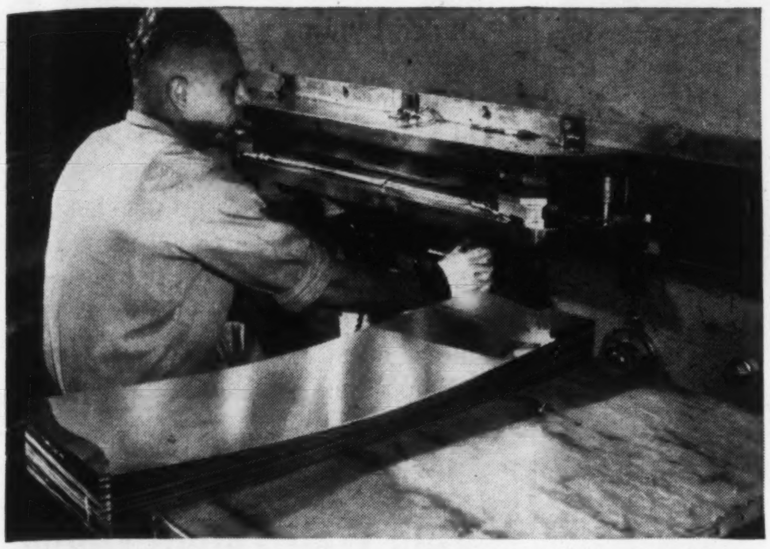
Domain walls

Generally, ferrites can be broken up into small units called domains. The induction in each domain usually points in one direction but the induction may be influenced by a magnetic field to point in different directions. For example, domain walls or sheets between the domains, while under the influence of a magnetic field, move in such a manner as to enlarge domains whose induction is closest to the direction of the magnetic field. Consequently, Mr. Galt says, ferrite devices that depend upon domain wall motion will not work as fast at very low temperatures as they do at room temperature.

The results of work on domain

Production Takes A Short-Cut

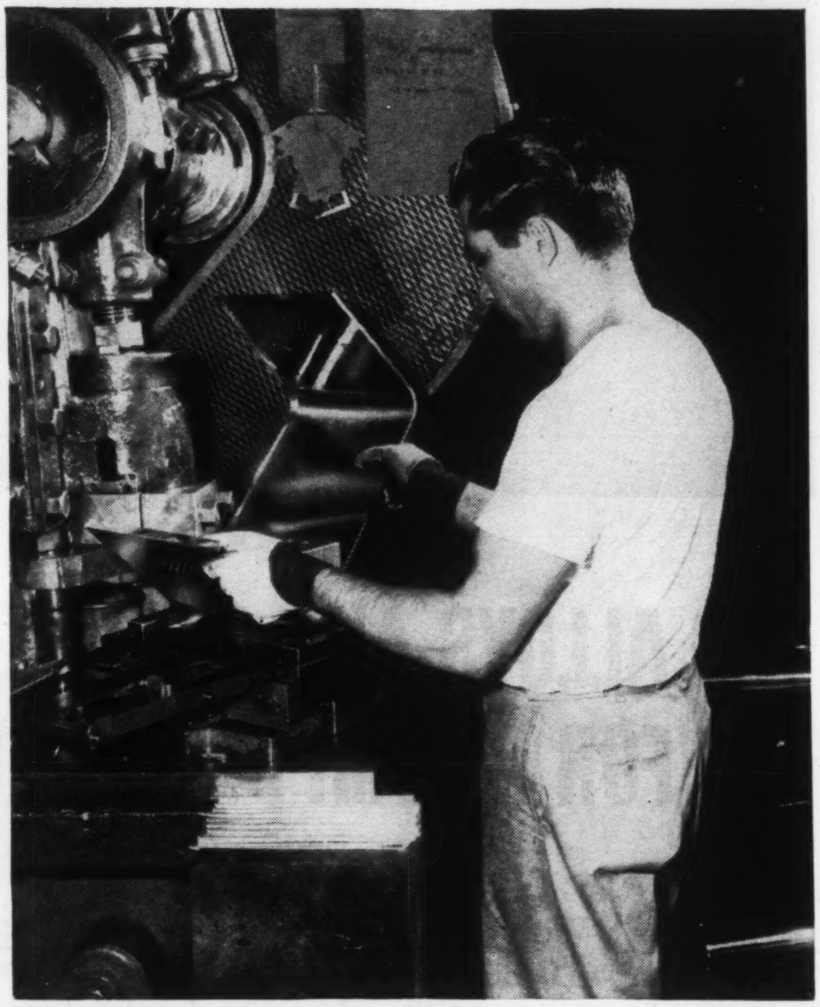
With Pre-Plated NICKELOID METALS



Sheet of Nickeloid chrome-steel that will be used for breadbox is blanked, with punch-out perforations for ventilation and indented shelf supports. Uniform pre-plated finish reduces rejects.

Edges of Nickeloid chrome-steel sheet are turned up 1/2" in forming press. Nickeloid is easily worked with standard methods.

Breadbox body frame is spot welded to the preformed bottom and back pieces, with no visible oxidation. Parts then move to assembly.



Two bends are made on press to give the breadbox its rectangular shape. Operation causes no marring of surface or dulling of finish.

No Cleaning or Post-Plating — Easily Worked With Standard Production Methods

No cleaning solutions, plating tanks or polishing wheels on the production line at Lincoln Metal Products Co., Brooklyn, N.Y., manufacturer of fine pantryware. Lincoln eliminates these costly intermediate steps by using Nickeloid preplated chrome-steel and copper-steel. These versatile design materials speed trouble-free production, reduce rejects, prolong tool life. They are readily worked with standard production methods, as shown here. Parts move from fabrication — to assembly — to packing, with no dulling or marring of the pre-plated finish, since Mar-Not protective covering is used. No cleaning, plating, polishing is needed. Nickeloid Metals are available in pre-plated finishes of chrome, nickel, copper or brass on steel, zinc, copper, brass and aluminum. Sheets, strips, coils — a wide range of finishes and patterns.

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AMERICAN NICKELOID COMPANY

Peru 6, Illinois

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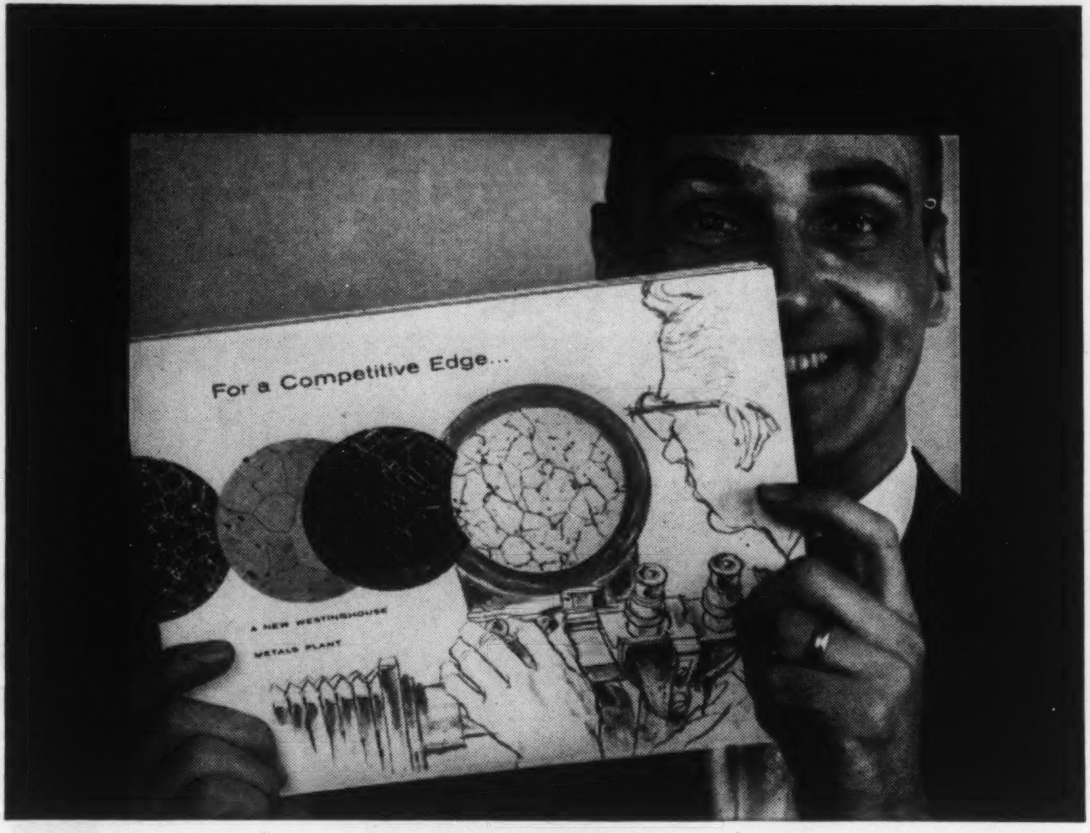
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The booklet takes you on a tour of the new Westinghouse metals plant at Blairsville, Pa. Pilot plant facilities here can help you explore full production conditions and create prototype quantities for wrought alloys and molded-metal products. Some production capacity can be made available for fast, dependable delivery of metal products.

Arrange to see the 16-mm, full-color, 22-minute Westinghouse film, *This New World of Metals*. Write Westinghouse Electric Corporation, Materials Manufacturing Department, Blairsville, Pennsylvania. J-05003

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wall motion have added much to understanding the behavior of ferrites. However, Mr. Galt says that there are many things yet to be learned of the ferrites. For instance, there is no very satisfactory picture of the precise way the valence electrons rearrange geometrically or of their quantum-mechanical energy levels. Also, more must be learned about loss mechanisms in these materials.

Thin Wall Teflon Tubing Used in Tight Areas

A thin walled Teflon spaghetti tubing has been introduced by W. S. Shamban & Co., 11617 W. Jefferson Blvd., Culver City, Calif., for use in electrical and electronic parts that require sharp tubing bends in restricted corners. The tubing is made in wall thicknesses from 0.005 to 0.010 in. According to the producer, the Teflon tubing is competitive in price with vinyl tubing, yet is more flexible and easier to handle.

Two Black Phenolics for Appliance Parts

The other black phenolic, a fast ing compounds are available for appliance and electrical parts. One compound, produced by General Electric Co., Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass., and designated GE 12929, is designed to withstand temperatures up to 400 F. GE says the phenolic is suitable for glossy appliance and camera parts and black piano keys.

The other black phenolic, a fast curing, two-step molding material, is produced by Bakelite Co. Div., Union Carbide Corp., 260 Madison Ave., New York 16. Field evaluation tests show the compound, called BMM-7000, cures

MATERIALS *styrene to glass*

METHOD *bonding with industrial adhesives*

This seemingly impossible production bonding problem (styrene-to-glass without discoloration or solvent attack) was solved by Terre Haute Advertising Company, Terre Haute, Indiana, with a 100% solids epoxy paste — BONDMASTER M653.

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The flexibilized epoxy adhesive which enabled this attractive desk thermometer to be mass produced wasn't "custom formulated" for the job. It is one of more than 30 "stock" metal-and-plastics-to-themselves-and-to-each-other adhesives in the varied BONDMASTER line.

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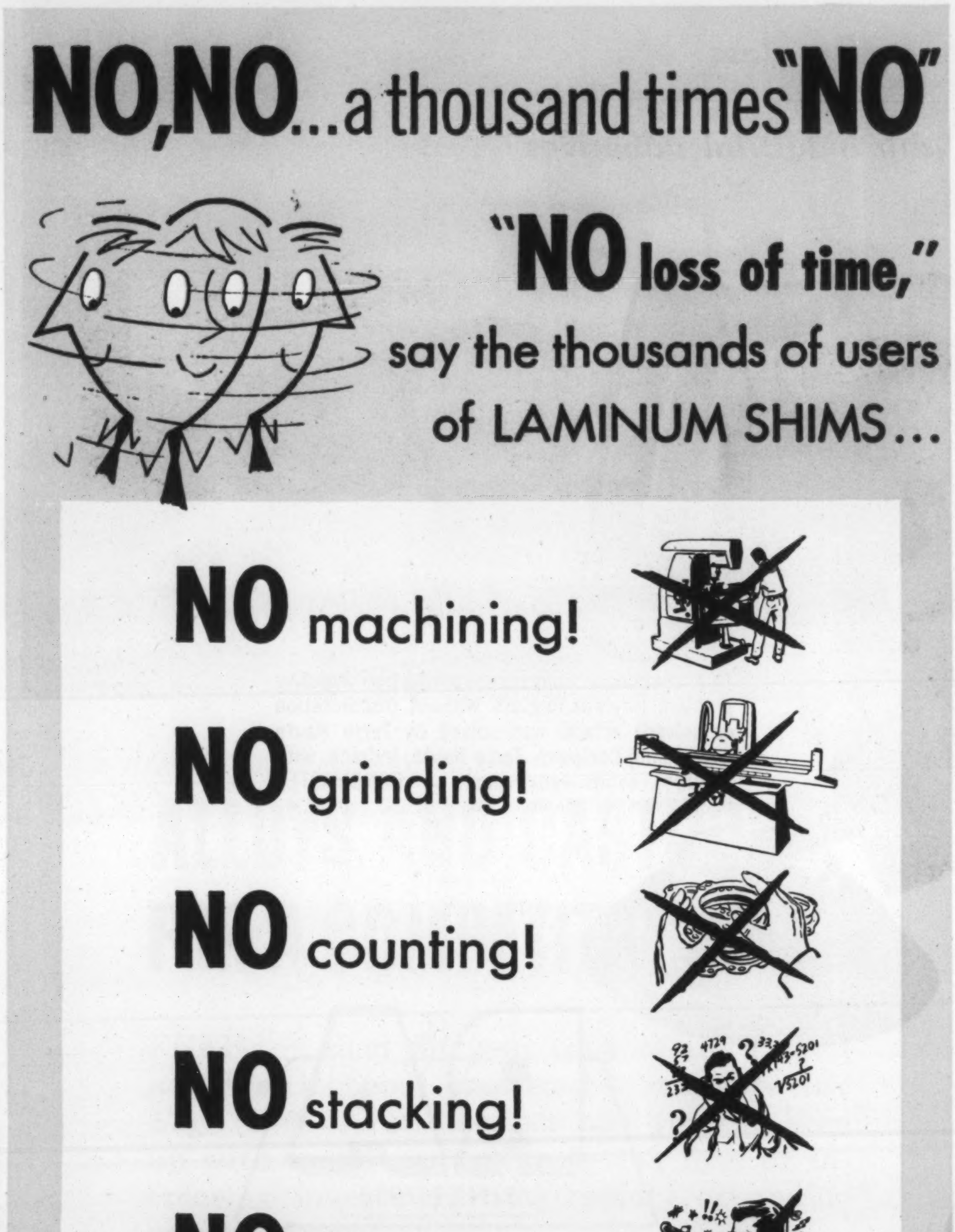

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STAINLESS STEEL with laminations of .002" or .003"	ALUMINUM with laminations of .003" only
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LAMINATED SHIM COMPANY, INC.
Shim Headquarters since 1913
1611 Union Street, Glenbrook, Conn.

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PROPERTIES OF GE 12929

Property	Value
Tensile Strength, psi	7000
Notched Izod Impact Strength, ft-lb/in.	0.34
Flexural Strength, psi	10,000
Modulus in Flexure, psi	1×10^6
Compressive Strength, psi	25,000
Water Absorption, %	0.45
Rockwell Hardness	M100
Heat Distortion Temp, F	340
Dielectric Strength (60 cycles), v/mil	
75 F	300
210 F	125
Power Factor (60 cycles)	0.45
Dielectric Constant (60 cycles)	10.0

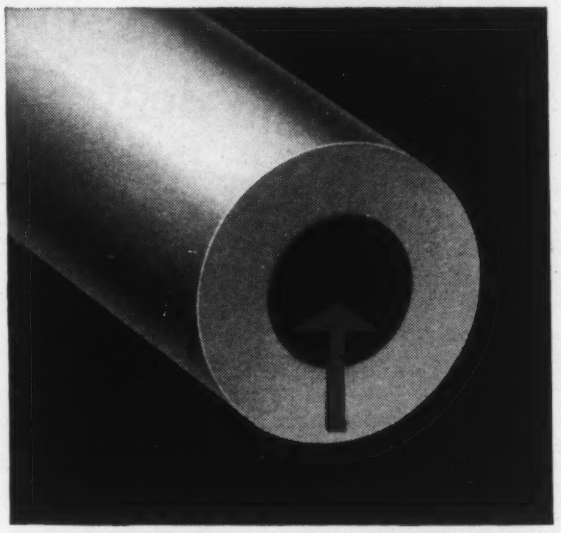
50% faster than presently available one-step and two-step phenolics. According to the producer, the apparent modulus of elasticity of BMM-7000 is 50,000 psi after a cure of 50 sec at 335 F. A conventional one-step phenolic is said to require a cure time of 75 sec at 335 F to provide the same rigidity. Bakelite's compound is a woodflour-filled phenolic designed especially for electrical parts.

Rubber Compound

Stillman Rubber Co., 5811 Marilyn Ave., Culver City, Calif., has developed a rubber compound for difficult sealing applications, such as poppets and dynamic and static seals. Called SR 251-70, the vulcanized rubber compound is said to have good compression set properties at high temperatures. It is also claimed to have good oil and solvent resistant properties at temperatures ranging from –65 to 500 F.

Solvent Loosens Parts Embedded in Plastics

A nonflammable solvent has been developed by Emerson & Cuming, Inc., 869 Washington St., Canton, Mass., to recover items



a hole here is a hindrance... a hole here is a help

Crucible Hollow Tool Steel sections, cut to length, save you time and money when you make ring-shaped, or tubular parts, or tools with a center hole. Because these tool steel sections are already drilled through when you get them, you don't have to bore, drill, cut-off or rough-face. Production time goes down, and most scrap losses are eliminated.

Five popular grades of Crucible tool steel are available immediately from warehouse stock, in hollow-disc form. They are KETOS oil-hardening, SANDERSON water hardening, AIRDI 150 high-carbon, high-chromium, AIRKOOL air-hardening, and NU-DIE V hot-work tool steels. Order the O.D. and I.D. combination, and length and thickness you need.

Let your Crucible representative show you how hollow tool steel sections can reduce production time, and save you money. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE **first name in special purpose steels**

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Canadian Distributor—Railway & Power Engineering Corp., Ltd.

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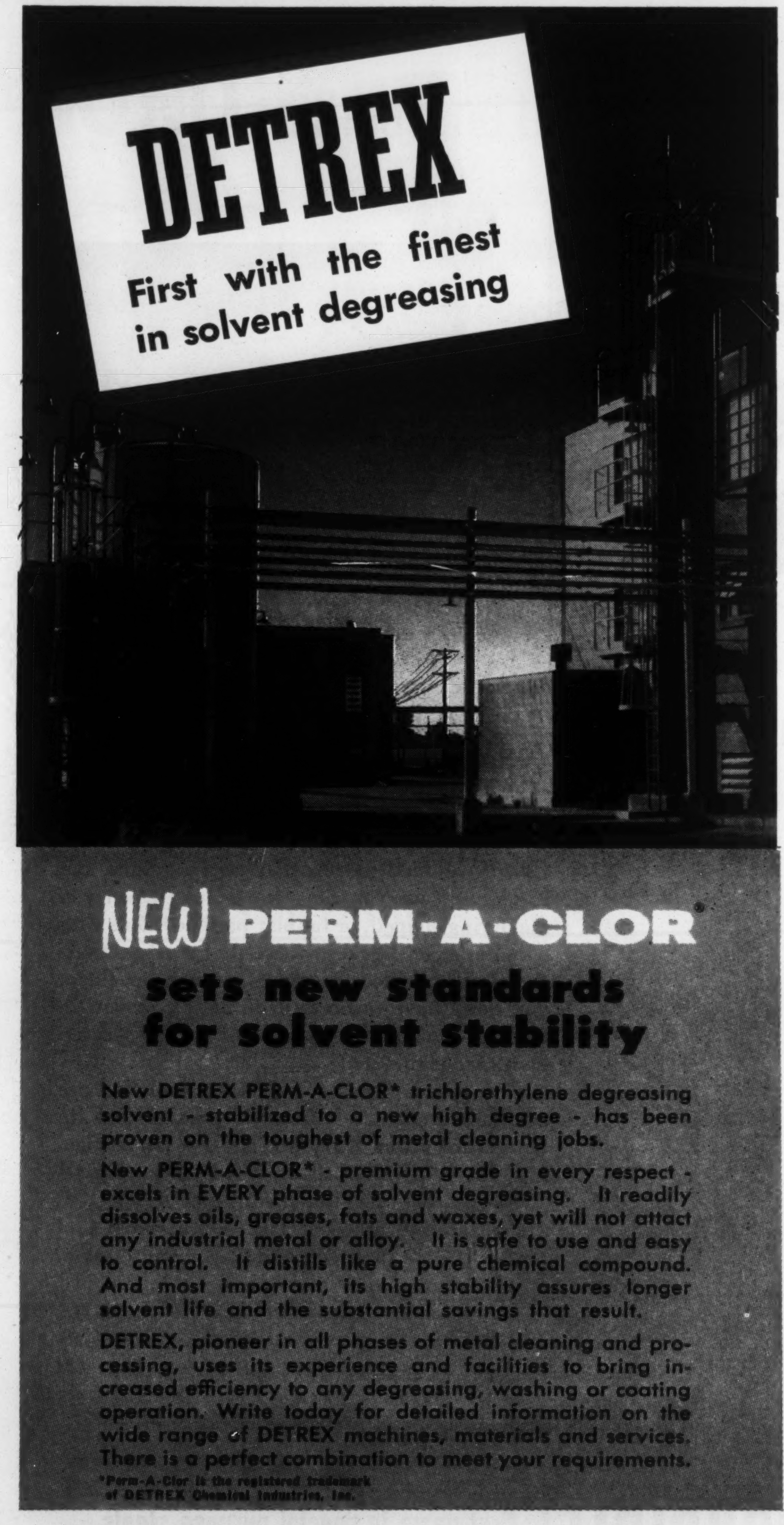

NEW PERM-A-CLOR®
sets new standards for solvent stability

New DETREX PERM-A-CLOR* trichlorethylene degreasing solvent - stabilized to a new high degree - has been proven on the toughest of metal cleaning jobs.

New PERM-A-CLOR* - premium grade in every respect - excels in EVERY phase of solvent degreasing. It readily dissolves oils, greases, fats and waxes, yet will not attact any industrial metal or alloy. It is safe to use and easy to control. It distills like a pure chemical compound. And most important, its high stability assures longer solvent life and the substantial savings that result.

DETREX, pioneer in all phases of metal cleaning and processing, uses its experience and facilities to bring increased efficiency to any degreasing, washing or coating operation. Write today for detailed information on the wide range of DETREX machines, materials and services. There is a perfect combination to meet your requirements.

*Perm-A-Clor is the registered trademark of DETREX Chemical Industries, Inc.

DETREX CHEMICAL INDUSTRIES, INC.
BOX 501, DETROIT 32, MICHIGAN

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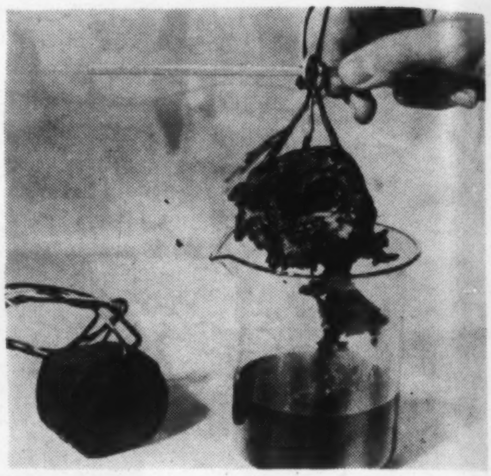


Wires *are loosened from casting resin with nonflammable solvent.*

embedded in epoxy and polyester resins and in polysulfide and silicone rubbers. Called Eccostrip 57, the solvent usually takes several days to completely loosen the embedded material from the resin or rubber. According to the producer, the solvent can be reused.

Copper Addition Aids Machining of Steel

The addition of copper to cold finished steel bars is said to greatly improve the machinability of these bars. Recently, La Salle Steel Co., 1420 150th St., Hammond, Ind., announced the availability of copper-containing steel bars, called "Stressproof with Copper Controlled Chemistry," having a guaranteed minimum yield strength of 100,000 psi in sizes through 2 in., and 90,000 psi in sizes from 2 to 3⅜ in. Other mechanical properties are not guaranteed, according to the producer.

According to La Salle, "Stressproof steel bars with Copper Controlled Chemistry will machine faster than any other carbon or alloy steel at the same strength and of the same carbon content. Both laboratory and field tests indicate approximately a 10% increase in machinability compared

For more information, circle No. 514 ➤

CHICAGO AND NORTH WESTERN

HOW THE SILICONES MAN HELPED...

Light up the life of a double-decked commuter

Greater comfort for commuters . . . and increased efficiency for railroads in these double decked coaches now in service on the Chicago and North Western Railroad. Brighter, roomier, air conditioned . . . and passenger capacity more than doubled. Problem? Greatly increased power demand but no more space for motor generating equipment. Solution? Class H insulation with Silicones.

The engineering staffs of Waukesha Motor Company and Harnischfeger Corporation, cooperating with the C&NW, designed and built a Class H generator using UNION CARBIDE Silicones as the insulating resin. Silicones stand up under temperatures and loads that break down other insulating materials. The result is a unit no larger than those previously used, but supplying sufficient power to meet the new demands *plus* any overload condition.

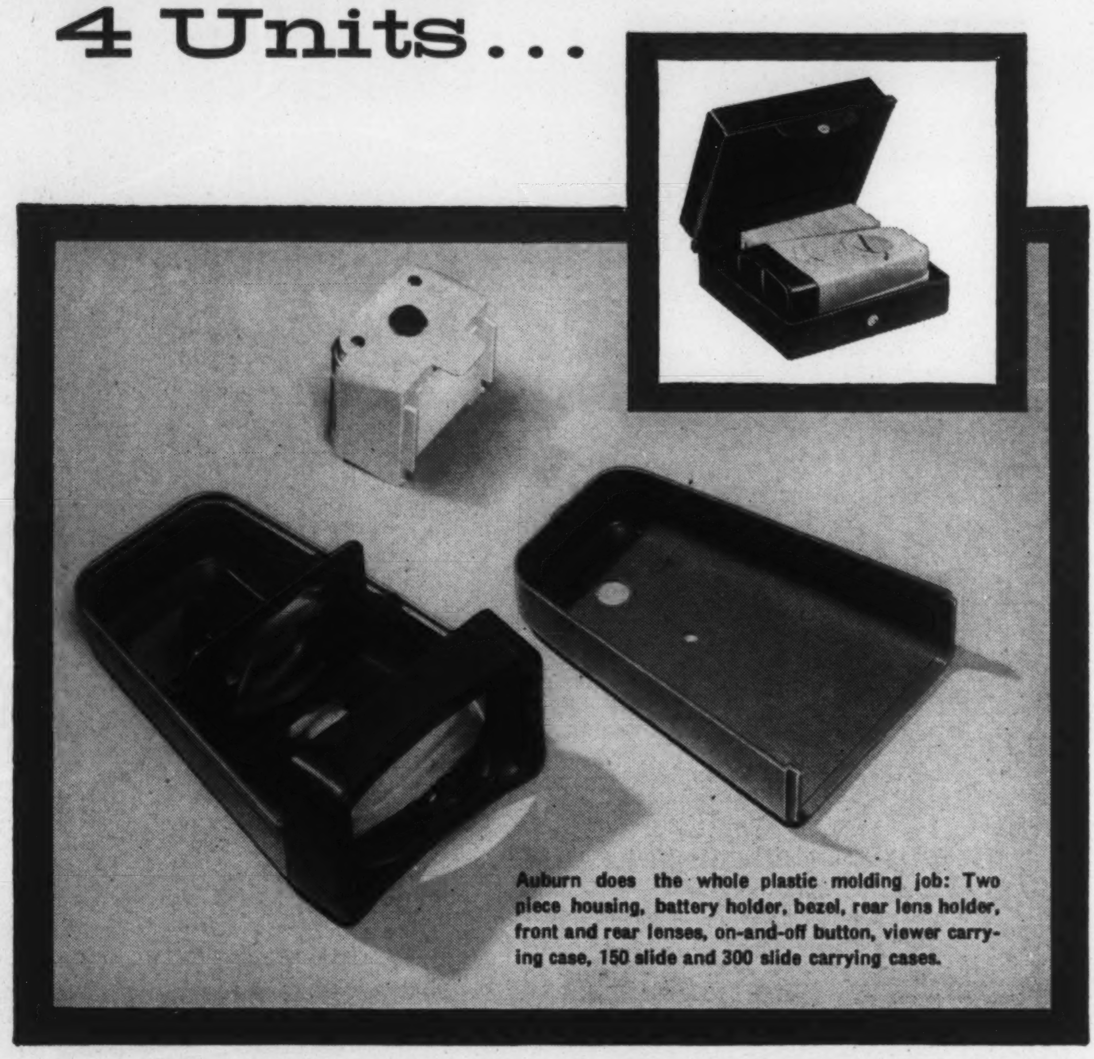
This is another example of how the UNION CARBIDE Silicones Man has helped solve an "impossible" problem. To obtain more information on the many advantages of silicone insulation, a booklet—"Class H Insulation with UNION CARBIDE Silicones" is available by writing to Dept. N-11, Silicones Division, Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.

UNION CARBIDE TRADE-MARK **SILICONES**

The term "Union Carbide" is a registered trade-mark of UCC.

In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Toronto 7, Ontario

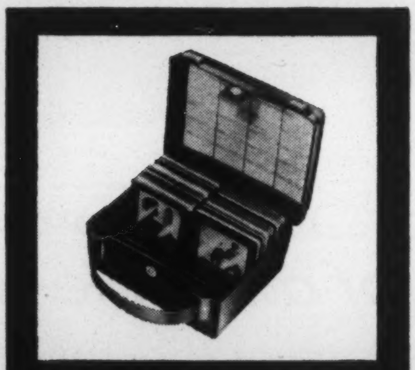
11 Components...
3 Materials...
4 Units...



Auburn does the whole plastic molding job: Two piece housing, battery holder, bezel, rear lens holder, front and rear lenses, on-and-off button, viewer carrying case, 150 slide and 300 slide carrying cases.

In One All-Plastic Auburn Package

Here's what we're doing for the manufacturer of a fast-selling 35 mm. slide viewer: Producing an 8-component viewer in injection-molded high impact styrene, with two acrylic lenses so accurately molded that no grinding or polishing is necessary. Also producing three carrying cases – one for the viewer, two for slides. These cases are one-piece hinged polyethylene – a delicate job, but one we've thoroughly mastered. Quite a package! But it's coming through with the high-speed, low-cost production that Auburn molding always gives. And our one-stop plastic service can do the same kind of *complete* job for you.



api AUBURN PLASTICS, INC.
AUBURN, NEW YORK
FORMERLY AUBURN BUTTON WORKS, INC.
ESTABLISHED 1876

For more information, turn to Reader Service card, circle No. 564

to regular Stressproof steel bars."

Other benefits derived from the copper addition are said to be improved tool life, good corrosion resistance and improved physical and mechanical properties. The company says field evaluation tests show that the addition of copper to Stressproof results in a 25 to 150% improvement in tool life during machining operations.

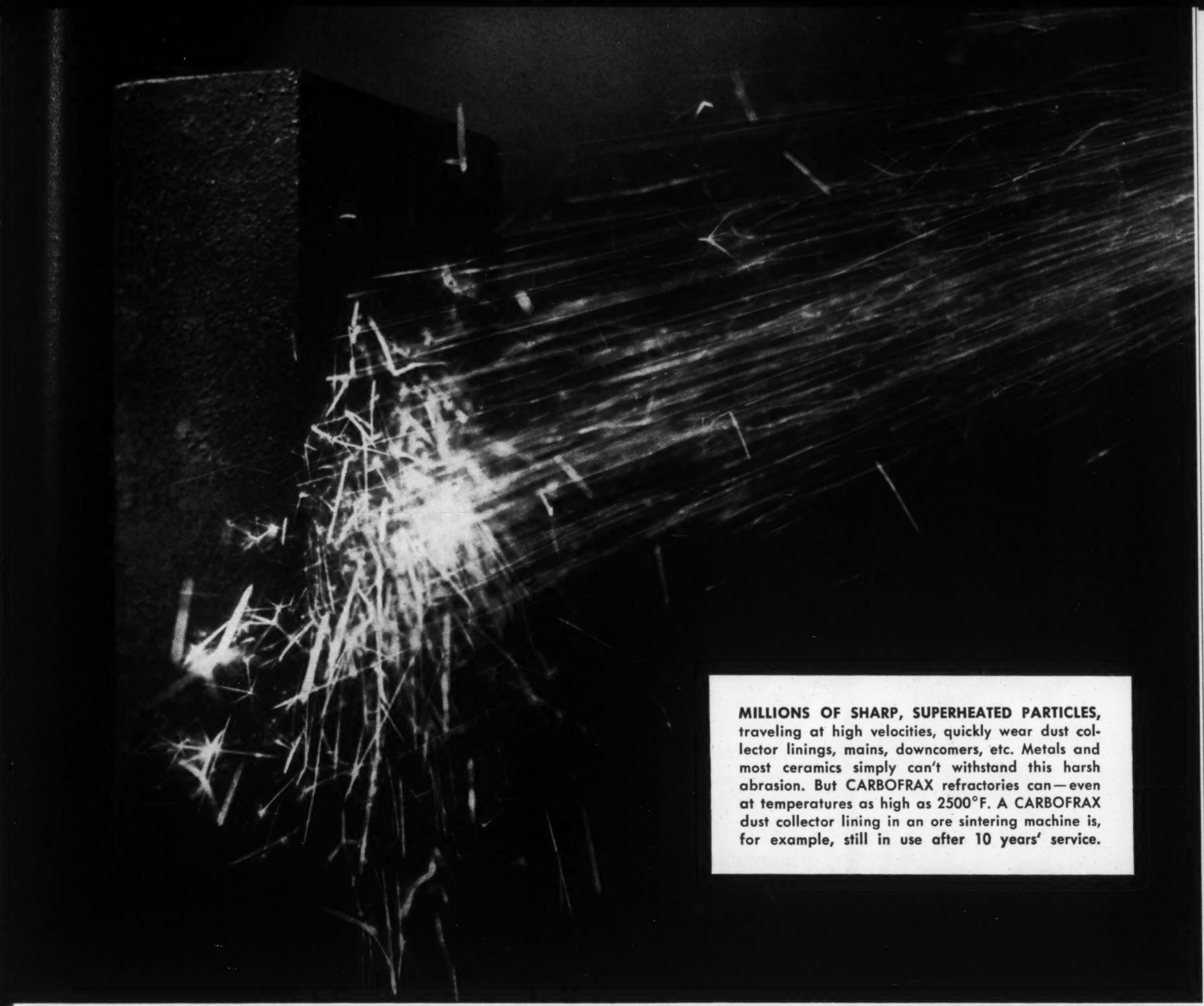
The chemical composition of regular Stressproof steel bars is: 0.40-0.48 carbon, 1.35-1.65 manganese, 0.040 max phosphorus, 0.24-0.33 sulfur and 0.15-0.30 silicon. Just how much copper is added to the steel bars was not revealed.

Aluminum Foam May Compete with Wood

Foamed aluminum, developed recently by Bjorksten Research Laboratories for Industry, Inc., can be sawed, nailed, cemented, screwed and worked like wood and may someday replace wood in a number of applications. The research organization has completed negotiations with a newly formed company, Foamalum Co., Box 443, Janesville, Wis., to make aluminum foam aquaplanes and various types of floats, such as those used in carburetors, stock watering tanks and toilet tanks.

Basically, the process for making the foam aluminum consists of mixing gas forming chemicals in molten aluminum. Gas bubbles, formed in the molten aluminum, honeycomb the metal with air cells upon cooling and produce a

***Aluminum** looks like this after going through new foaming process.*



MILLIONS OF SHARP, SUPERHEATED PARTICLES, traveling at high velocities, quickly wear dust collector linings, mains, downcomers, etc. Metals and most ceramics simply can't withstand this harsh abrasion. But CARBOFRAX refractories can—even at temperatures as high as 2500°F. A CARBOFRAX dust collector lining in an ore sintering machine is, for example, still in use after 10 years' service.

Refractories ... to resist abrasion

Exceptional resistance to abrasion—whether caused by tiny gas-borne particles or sliding steel billets—is one of the most useful properties of several of Carborundum's unique refractory materials. For example, when used in the exhaust lines of gasoline catalytic cracking units in temperatures ranging up to 1200°F, these refractories lasted 3 years, as compared to alloy rings which lasted for 6 months.

And when abrasion is combined with higher temperature, the exceptional resistance of these super refractories becomes even more apparent and useful. As skid rails in furnaces which heat 6-lb. billets to 2250°F—pushing 250 slugs an hour—CARBOFRAX® silicon carbide refractories need one-third the replacement, one-third the labor and one-third the down-time of ordinary rammed chrome ore hearths. Other successful applications include: dust collectors, gas scrubbers, transfer pipe lines, hydro cyclones and process equipment parts, to name but a few.

Many applications call for other properties in combination with wear resistance. Among Carborundum's many materials are refractories that also offer excellent heat shock resistance with sufficient hot strength to withstand 25 psi at 3128°F. Others provide unique resistance to corrosion as well as abrasion. These properties are but a few of those to be found in super refractories pioneered by Carborundum. Among them, you are almost certain to find answers to your refractory and high-temperature problems. For help, fill in and mail this coupon:

CARBORUNDUM

Registered Trade Mark

For more information, turn to Reader Service card, circle No. 383

MAIL THIS COUPON TODAY

Dept. R117, Refractories Division,
The Carborundum Company, Perth Amboy, N. J.

Please send me:

☐ Forthcoming issue of Refractories Magazine
☐ Bulletin on Properties of Carborundum's Super Refractories
☐ Here is a description of my high temperature problem. Can you help me?

Name__________ Title__________

Company__________

Street__________

City__________ Zone_____ State__________

Carbon-Graphite

FOR DESIGN PROBLEMS INVOLVING...

CORROSIVE CHEMICALS OR GASES
LUBRICATION DIFFICULTIES
TEMPERATURE VARIATIONS
CLOSE TOLERANCES OR COMPLICATED SHAPES
WEIGHT RESTRICTIONS
CONTROLLED FRICTION
ELECTRICAL CONDUCTIVITY
ELECTRICAL ARCING
COST
. . . and many others

FLUID COUPLING SEALS
ROTARY SHAFT SEALS
PUMP BEARINGS
GAS TURBINE SEALS
PUMP VANES
OIL & GREASE SEALS
PISTONS

Stackpole carbon and graphite—used singly, in combination, or mixed with metal powders—bring design flexibility to hundreds of mechanical engineering problems.

Special grades are constantly being developed to meet specific requirements.

Ask your local Stackpole Field Engineer or send details of your problem for recommendation.

CARBON GRADES FOR MECHANICAL APPLICATIONS

Grade	Hardness	Strength	Apparent Density	Max. Safe Oper. Temp. ° F	Typical Applications
SK 16	45	6000	1.75	250	Water Pumps
SK 182	70	8000	1.77	350	
SK 180	80	7000	1.75	650	Corrosive Chemicals
469	80	8000	1.80	1200	High speed, High Temperature Aircraft
SK 145	90	8000	1.80	800	
SK 187	80	9000	1.79	650	High Altitude Bearings
SK 188	65	7000	1.78	650	
SK 152	100	10000	1.75	650	Very hard material for bearings operating in liquid
SK 154	100	10000	1.75	650	
SK 157	75	7000	1.80	250	Appliance Seals
SK 176	80	7000	1.80	650	
SK 105	75	7000	1.60	500	Oil Seals
SK 175	75	7000	1.75	500	
304	80	9000	1.79	650	Vanes & Bearings
331	50	7000	1.74	800	Turbine Rings
P87	70	6000	1.68	650	
Y20	40	3000	1.65	650	
SK 21	45	7000	2.70	250	
SK 87	70	7000	1.77	250	
SK 201	50	7000	1.79	800	
378	65	8000	1.78	650	
G560	45	4500	1.68	800	
HB1	35	3000	1.58	800	
HB1-4	30	4000	1.68	800	

NEW
High Temperature Carbon
Thanks to a new Stackpole material, bearings and seals used in gas turbines and other high temperature applications show minimum oxidation at temperatures up to 1200°F compared to the usual limit of 800°F for non-treated materials.

STACKPOLE

STACKPOLE CARBON COMPANY, *St. Marys, Pa.*

For more information, turn to Reader Service card, circle No. 454

lightweight, fairly strong material. According to the producer, the process is capable of producing a material ranging in density from 12 to 40 lb per cu ft. The material can be made either as a closed cell foam (floating) or as a water absorbent sponge.

Potential uses include fence, mine, dock and telephone posts. The material should also find use as a core material in aircraft structures and wall and floor panels.

Copper Clad Laminate Can Be Printed, Plated

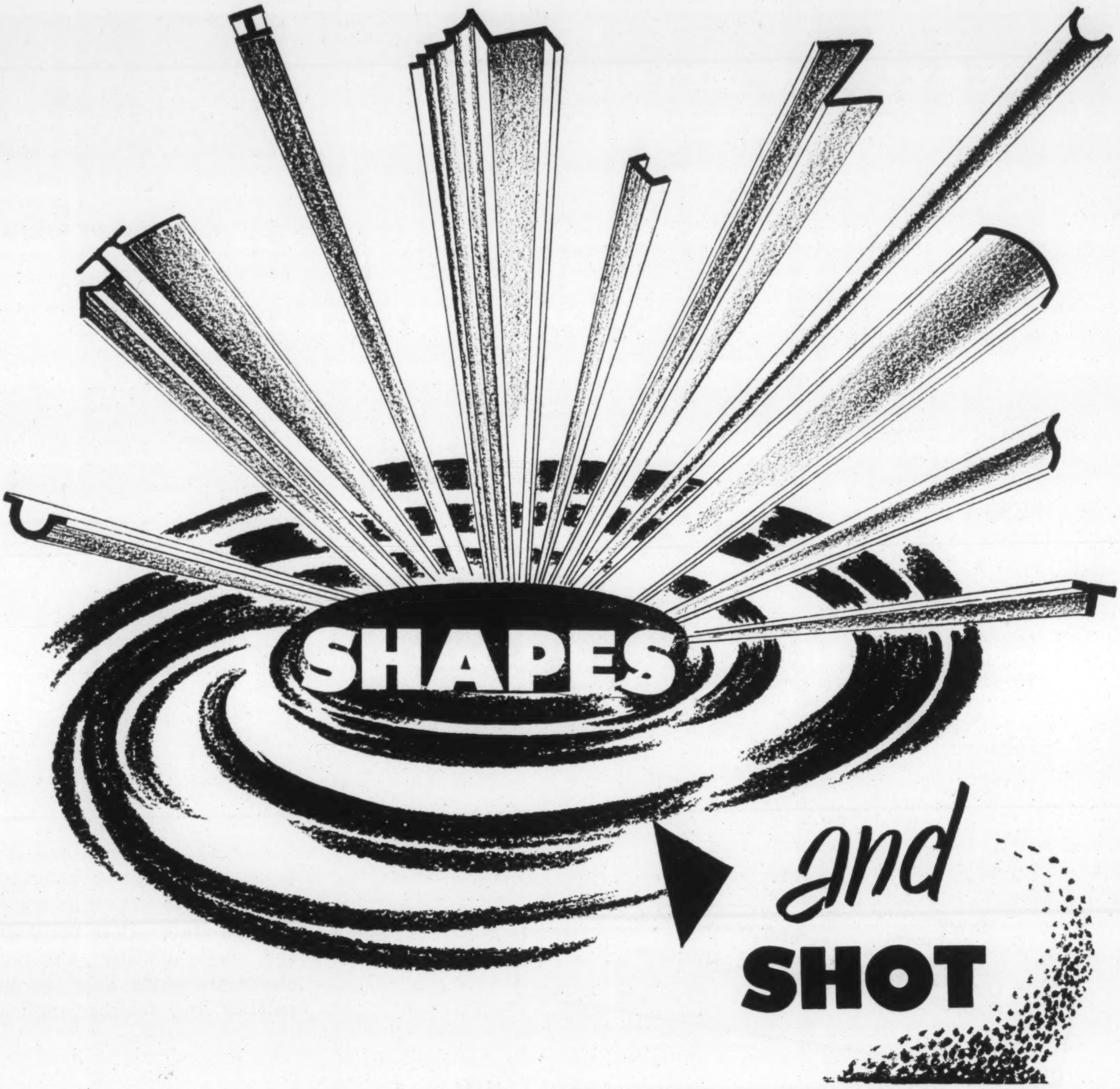
A copper clad laminate for printed electronic circuits has been announced by Taylor Fibre Co., Norristown, Pa. Designated Cu-246, the material is a paper-base laminate made with a special plasticized phenolic resin.

The copper foil used on the laminate is rolled copper having a 99.5% minimum purity. It has a surface adaptable to silk screening, offset printing, standard photoengraving, and semiprecious and precious metal plating.

According to the producer, Cu-246 can be cold punched and cold sheared in thicknesses up to 1/16 in. The laminate is made in sheets approximately 37 x 49 in. and in thicknesses from 0.020 to 0.250 in., with copper on one or both sides.

Silicone Rubber, Resin for Hot Applications

Dow Corning Corp., Midland, Mich., has recently introduced a new silicone resin and an improved silicone rubber. The silicone resin, designated R-7141, is recommended for vacuum molding of such complex structural parts as radomes, aircraft duct work



Basic shapes from Angles to Zees, and specialized shapes for architectural trim and truck bodies are available from *stock* in the principal corrosion resistant alloys. Many an odd or unusual shape is a stock item, too, since more and more companies have redesigned their small parts to capitalize on the savings in machining afforded by using preformed shapes.

Shot? We specialize in that, too—stocking foundry alloys, and making shipments in quantities from handfuls to carloads in Nickel, Silico-Manganese, Iron Foundry Inoculants, Vanadium, Chromium, Silicon, Titanium, Manganese for foundry corrosion resistant alloying purposes.

Whether it be shapes, shot, or anything else, selecting the one right kind of material in the corrosion resistant field is important. Recognizing this we're ready to advise you, since we stock all the principal alloys, we can and do give unbiased opinions.

So, when you need anything in the corrosion resistant line, think of Whitehead. Eight conveniently located warehouses with more than 20,000 items to choose from — products of such leading producers as Alcoa, Inco, Anaconda, Vancoram, and many others. You'll find it will pay to Call WHITEHEAD first.

ALUMINUM • BRASS • BRONZE • CLAD METALS • COPPER • MONEL • NICKEL • INCONEL • PRIMARY NICKEL & FERRO ALLOYS • PLASTICS • STAINLESS STEEL

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METAL PRODUCTS COMPANY, INC.

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BERYLLIUM METAL

QMV Brand . . .

High Strength-to-Weight Ratio
Rigidity, Dimensional Stability, Machinability
High Thermal Capacity and Conductivity
High Melting Point
Exceptional Nuclear Properties

Typical uses:
Aircraft and Missile Structures
Guidance Assemblies
Reactor Components

FROM Brush

BERYLLIUM COPPER ALLOYS

BRUSH Be-Cu

Hardenable to RC-40 by simple heat-treatment
Cast or worked by any commercial process
High Electrical Conductivity with High Strength
Excellent Wear Resistance and Fatigue Strength
Good Corrosion Resistance and High Temperature Properties

Typical uses:
Electrodes, Contacts, and Wave-guides
Dies, Gears, and Cams
Springs and High Fatigue Applications

BRUSH is the primary producer of BERYLLIUM METAL and BERYLLIUM ALLOYS.

QMV BRAND BERYLLIUM is available in vacuum-sintered bar, wrought forms and machined assemblies.

Be-Nickel, Be-Aluminum, Be-Copper and special alloys are produced as casting alloy and master alloy.

Beryllium-Copper alloys are also available in wrought form.

Synthetic Mica and High-strength BeO refractories are other products of BRUSH Research.

Two new informative bulletins are going to press soon. Write about YOUR requirements to:

Beryllium Copper
Beryllium Metal

Brush Beryllium

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BERYLLIUM METAL
BERYLLIUM COPPER
BERYLLIUM MASTER ALLOYS
BERYLLIUM OXIDE

THE BRUSH BERYLLIUM COMPANY, 4301 PERKINS AVE., CLEVELAND 3, OHIO

For more information, turn to Reader Service card, circle No. 551

PROPERTIES OF RTV 501

Tensile Strength, psi	230
Elongation, %	250
Durometer Hardness	A30
Brittle Point, F	–100
Water Absorption (70 hr at 212 F), %	–1.4
Dielectric Strength, v/mil	460
Dielectric Constant	
10^2 Cycles	2.6
10^5 Cycles	2.5
Dissipation Factor	
10^2 Cycles	0.01
10^5 Cycles	0.003

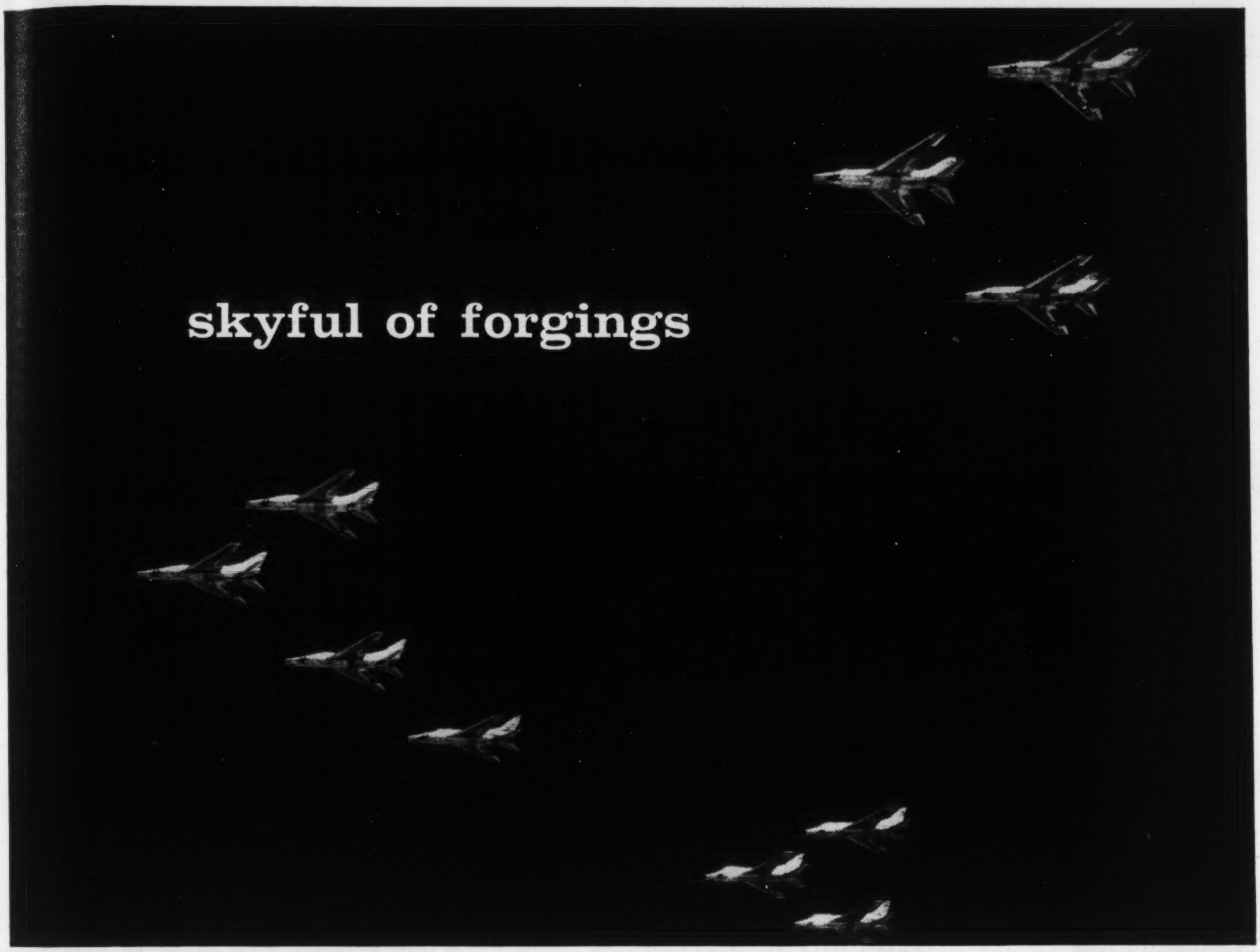
and high temperature missile parts. The cured resin is said to have good strength at high temperatures, good thermal stability, and good electrical properties.

The improved silicone rubber, RTV 501, is a room temperature vulcanizing rubber that is said to retain its rubber-like properties over a temperature range of –70 to 500 F. The improved rubber is said to have long shelf life (six months) and good handling and blending properties in the unvulcanized state. It is recommended for encapsulating electric and electronic parts and for general potting and sealing applications.

Preplated Metal Can Be Deep Drawn

A new development in preplated metal, known as specification plate on ChromSteel, is said to eliminate costly piece plating of parts that require deep draws and severe bends. According to the producer, Apollo Metal Works, 6650 S. Oak Park Ave., Chicago 38, the preplated metal can be stretched without danger of drawing out the luster of the satin chromium finish. The chromium finish is said to be durable and wear resistant and can be cleaned frequently during the life of the product.

Applications where the preplated metal can be used include home and commercial kitchen accessories, automotive trim and



"Hot" aircraft are *really* hot today. High engine temperatures and the increasingly greater temperatures throughout aircraft structure are constant problems of high speed flight.

But forgings and fasteners of tough, heat resistant alloys are pushing back this "heat barrier", thanks to new metallurgical developments which greatly increase their forgeability and machinability.

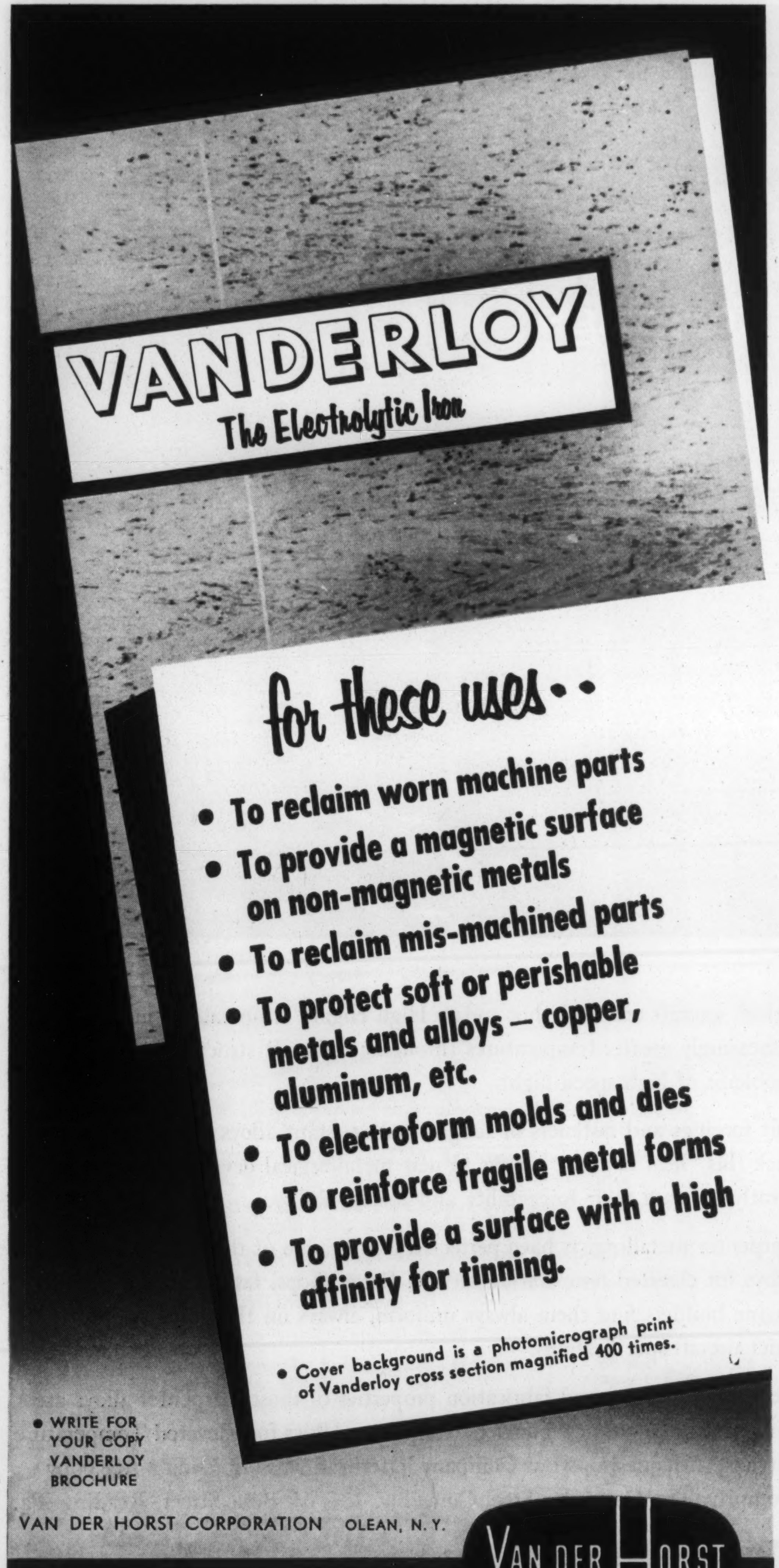
Carpenter metallurgists have perfected a full range of these more-workable alloys for elevated temperature service. Forge shops, fastener-makers and engine builders find them always uniform, always on the "plus" side of strict aircraft specifications.

Design, application and fabrication properties of these Carpenter alloys are covered fully in our new booklet, "Carpenter Alloys for Elevated Temperature Service". A request on your Company letterhead will bring you a free copy promptly. The Carpenter Steel Company, 135 W. Bern Street, Reading, Pa.

Carpenter STEEL

Improved alloys for elevated temperature service

For more information, turn to Reader Service card, circle No. 391



VANDERLOY
The Electrolytic Iron

for these uses..

- To reclaim worn machine parts
- To provide a magnetic surface on non-magnetic metals
- To reclaim mis-machined parts
- To protect soft or perishable metals and alloys — copper, aluminum, etc.
- To electroform molds and dies
- To reinforce fragile metal forms
- To provide a surface with a high affinity for tinning.

- Cover background is a photomicrograph print of Vanderloy cross section magnified 400 times.

- WRITE FOR YOUR COPY VANDERLOY BROCHURE

VAN DER HORST CORPORATION OLEAN, N. Y.

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LOS ANGELES, CALIFORNIA* CHICAGO, ILLINOIS
HILVERSUM, HOLLAND

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West Coast Affiliate

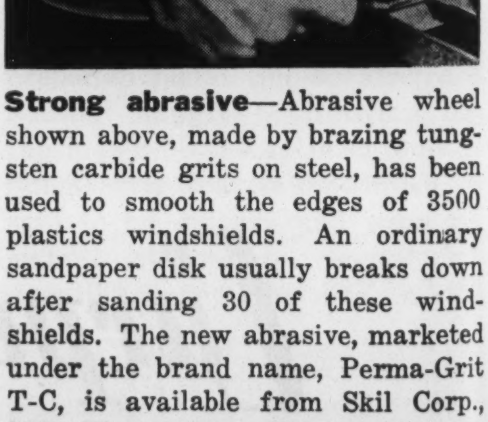
accessories, cabinet trim, bathroom accessories, fluorescent and recessed light brackets, dispensable paper and towel racks, and soap dishes.

Strain Gage Detects Changes in Metals

A newly developed optical strain gage has been designed specifically to check the variation in modulus of elasticity of a metal at high temperatures. It can also be adapted to check the degree of surface strain produced in a metal by heat cycling.

With proper calibration, the instrument can detect changes in metals at high temperatures in units as small as 20 millionths of an inch. Developed at Westinghouse Electric Corp., the instrument, roughly 1½ in. long, ¾ in. wide and ⅝ in. high, consists of a metal framework to hold two tiny mirrors, one stationary and the other movable.

In operation, the gage is



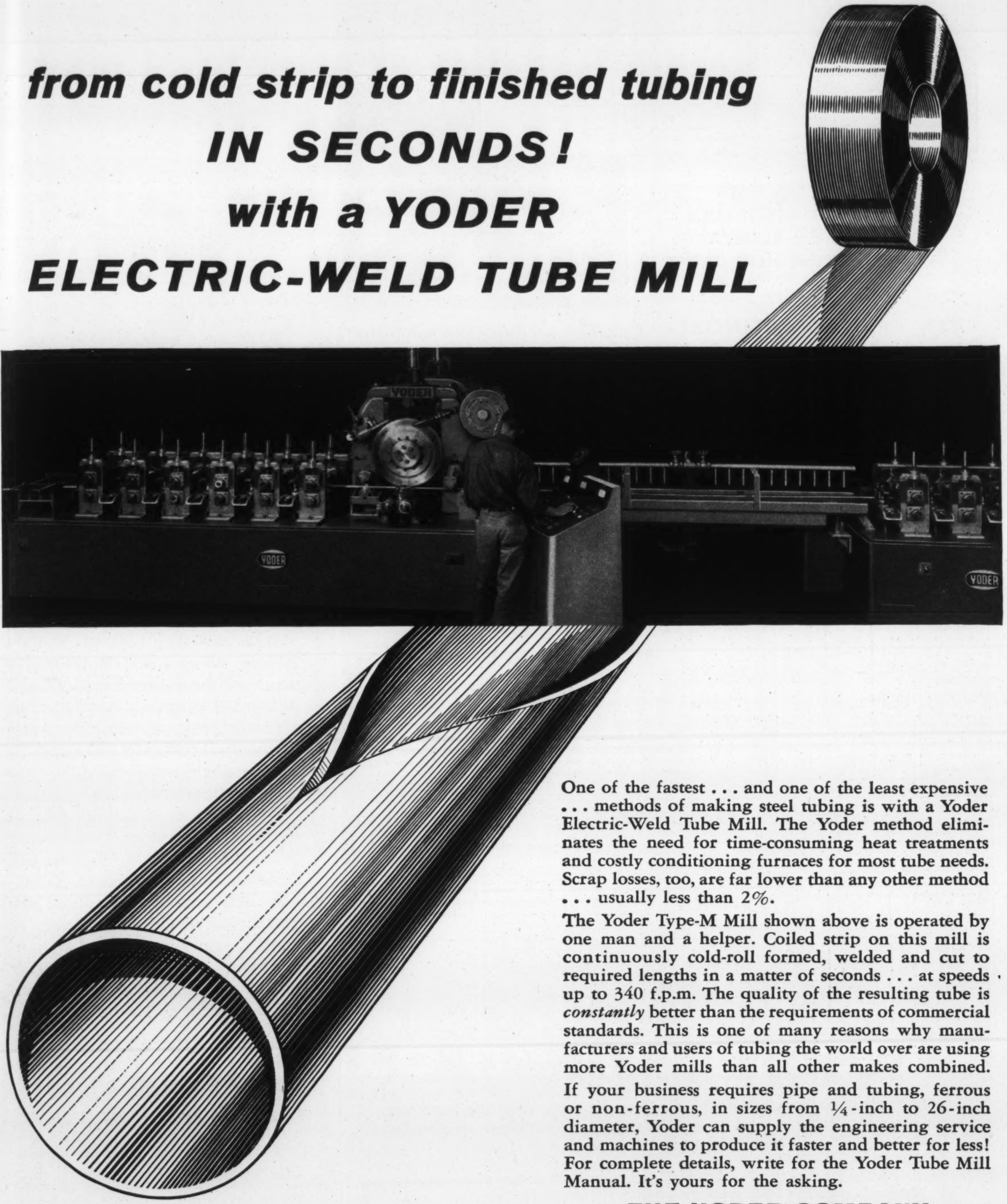
Strong abrasive—Abrasive wheel shown above, made by brazing tungsten carbide grits on steel, has been used to smooth the edges of 3500 plastics windshields. An ordinary sandpaper disk usually breaks down after sanding 30 of these windshields. The new abrasive, marketed under the brand name, Perma-Grit T-C, is available from Skil Corp., 5035 Elston Ave., Chicago 30.

from cold strip to finished tubing

IN SECONDS!

with a YODER

ELECTRIC-WELD TUBE MILL



One of the fastest . . . and one of the least expensive . . . methods of making steel tubing is with a Yoder Electric-Weld Tube Mill. The Yoder method eliminates the need for time-consuming heat treatments and costly conditioning furnaces for most tube needs. Scrap losses, too, are far lower than any other method . . . usually less than 2%.

The Yoder Type-M Mill shown above is operated by one man and a helper. Coiled strip on this mill is continuously cold-roll formed, welded and cut to required lengths in a matter of seconds . . . at speeds up to 340 f.p.m. The quality of the resulting tube is *constantly* better than the requirements of commercial standards. This is one of many reasons why manufacturers and users of tubing the world over are using more Yoder mills than all other makes combined.

If your business requires pipe and tubing, ferrous or non-ferrous, in sizes from 1/4-inch to 26-inch diameter, Yoder can supply the engineering service and machines to produce it faster and better for less! For complete details, write for the Yoder Tube Mill Manual. It's yours for the asking.

THE YODER COMPANY
5546 Walworth Avenue • Cleveland 2, Ohio

ENGINEERING
YODER
MANUFACTURING

PIPE AND TUBE MILLS (ferrous or non-ferrous)
COLD ROLL FORMING MACHINES
ROTARY SLITTING LINES

For more information, turn to Reader Service card, circle No. 380

SPECIFIC REQUIREMENTS IN STEEL CASTINGS?

- √ TENSILE STRENGTH
- √ ABRASION RESISTANCE
- √ CORROSION RESISTANCE
- √ SUBSEQUENT HEAT TREAT

Rely on UNITCASTINGS! Manufacturers have learned to rely on Unitcast's Specification Steel Castings. They know Unitcast's modern production facilities and engineering "know-how" assure the finest steel castings of *consistent uniformity!*

Unitcast produces a complete range of cast steels, from plain carbon grades through the low alloy ranges—with subsequent heat treat service. Listed below are six basic steels produced by Unitcast. Variations or special steels on request.

CARBON STEEL CASTINGS

TYPE OF CASTING	PHYSICAL PROPERTIES Tensile Strength p.s.i.	Yield Point p.s.i.	Elongation In 2"	Reduction of Area	Brinell Hardness	GENERAL CHARACTERISTICS
LOW CARBON [Grade B Soft]	60,000	30,000	25%	40%	120-140	Comparable to SAE 1020. Ideal for carburizing purposes. Weldability excellent. High ductility.
MEDIUM CARBON [Grade B Medium]	70,000 [Min.]	38,000 [Min.]	24% [Min.]	36%	140-170	Comparable to SAE 1025. Good machinability. Above average physical properties. Weldability excellent. Good ductility.
MEDIUM HIGH CARBON [Grade B Medium High]	80,000	43,000	18%	30%	170-190	Comparable to ASTM-A-148-46T 80—40. Slightly higher carbon than "Medium" grade with higher tensile properties. Decreased ductility. Water quench will increase hardness. Pre-heating and post-heating recommended for welding.
HIGH CARBON [Grade B High]	85,000	53,000	17%	25%	179-217	Comparable to SAE 1045. Attained higher tensile properties result in slightly less ductility. Suitable for high surface hardness. Welding difficult unless pre-heated and post-heated.

ALLOY STEEL CASTINGS

PHYSICAL PROPERTIES* T-LOY 34	HEAT TREATMENT Normalized Drawn	Oil Quenched 1200°F Drawn	Oil Quenched 900°F Drawn	GENERAL CHARACTERISTICS
Tensile Strength p.s.i.	90,000	105,000	150,000	Comparable to SAE or AISI 8632. Oil quench produces excellent tensile strength properties ranging to 150,000 p.s.i., coupled with high ductility, wear resistance and immunity to temperature changes. Specific areas may be flame or induction hardened.
Yield Point p.s.i.	60,000	85,000	125,000	
Elongation in 2"	20%	17.0%	10.0%	
Reduction of Area	40%	35.0%	25.0%	
Brinnell Hardness	187-217	217-246	305-342	
T-LOY 42				
Tensile Strength p.s.i.	100,000	120,000	175,000	Superior to SAE or AISI 8640. Recommended when high strength and hardness are desired in the normalized and drawn condition. Deeper hardening obtained by oil quench and draw with tensile up to 175,000 p.s.i High degree of hardness will be attained with spot or flame and air cooling. Water quench not recommended.
Yield Point p.s.i.	75,000	100,000	145,000	
Elongation in 2"	12%	12%	10%	
Reduction of Area	25%	28%	25%	
Brinell Hardness	217-246	250-280	350-380	

* Physical properties based on a .505" test bar turned from a standard 1⅛" cast test coupon

NOTE: Certified copies of complete test records—plus special test reports on each heat of steel—are provided to Unitcast customers on request.

Let Unitcast's engineers help you select the *right* castings for your requirements. Write or call today for detailed specification sheets. No obligation, of course!

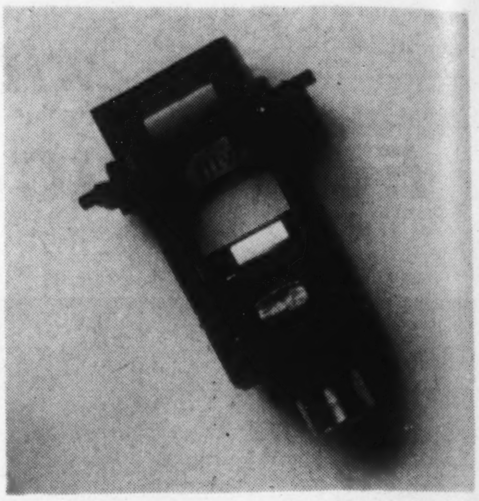
Unitcast

SPECIFICATION STEEL CASTINGS

UNITCAST CORPORATION • Toledo 9, Ohio

For more information, turn to Reader Service card, circle No. 531

What's new IN MATERIALS



Two tiny mirrors *are the heart of a high temperature optical strain gage.*

clamped to a metal surface; a beam of light is then aimed at one mirror, reflected to the other mirror and then back to the light source, where a scale indicates the angle of the return beam of light. When the sample is heated to test temperatures, a movable knife edge rotates slightly changing the mirror angle and in turn the light beam return angle.

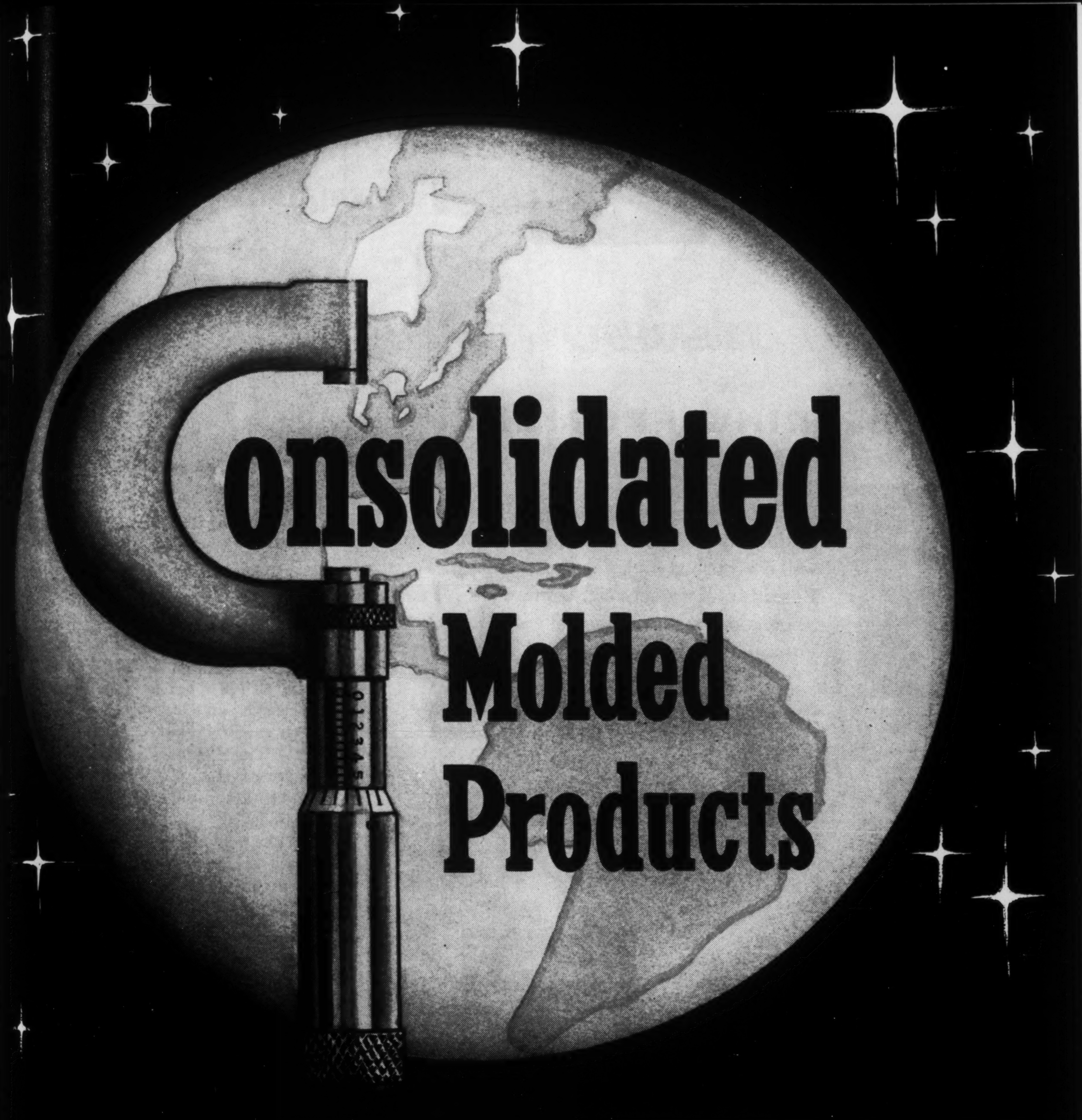
According to Westinghouse, an extremely high degree of accuracy is possible with the instrument, since there is no mechanical linkage between the gage and the measuring device. The mirrors consist of a silver brazed strip of platinum that is said to stay bright and reflective at temperatures as high as 1250 F.

Epoxy-Asbestos for Class B Insulation

Two improved types of epoxy-saturated asbestos paper insulations for Class B electrical applications have been announced by Johns-Manville Corp., 22 East 40th St., New York City. Known as types 71 and 72 Quinterra, the improved products are said to have good electrical and thermal properties.

Type 71 Quinterra is a high

For more information, circle No. 372 ➤



A WORLD OF EXPERIENCE

. . . goes into every Consolidated product. From blueprint to delivery, each plastics part is in the hands of skilled technicians to whom a customer's "well done" is the ultimate goal. Why don't you let us demonstrate what this experience and service can mean to you? You'll like the extra touches that mark a job by Consolidated.

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Bunting capability and leadership in the field of Cast Bronze Bearings and parts are well established and widely recognized. Today Bunting offers an equally comprehensive and responsible service in the field of Sintered Powdered Metal Bearings and parts.

Bunting's special knowledge and facilities make Sintered Powdered Metal products available in many applications not heretofore considered feasible. We can help you find the simplest answer to your individual problem, be it Cast Bronze or Sintered Metal.

A wide range of stock sizes of Bunting Cast Bronze and Sintered Powdered Bronze self-lubricating, plain and flange bearings, thrust bearings and bars are available from Bunting distributors everywhere in America.

Write for catalogs and your copy of the new 24 page Bunting Engineering handbook of Sintered Powdered products and their composition, manufacture and application.

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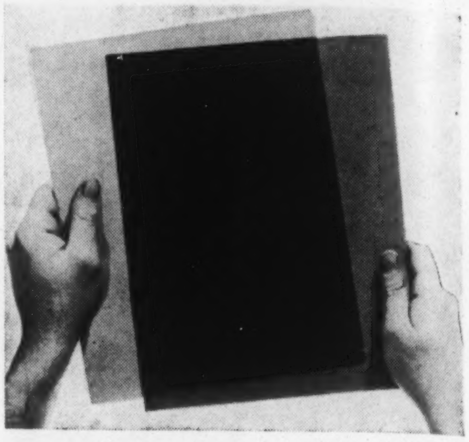


Epoxy-saturated *asbestos paper used for electrical insulation.*

resin content product with approximately 45 to 50% resin. Laboratory tests indicate that the product has a dielectric strength of over 700 v per mil, good tensile strength, and a moisture absorption factor of less than 2% after 24-hr immersion in water. The material is supplied in thicknesses of 4 and 5 mils as tape, cut sheets or rolls.

Type 72 Quinterra is a normal resin content product with approximately 20 to 30% resin. Heat aging tests show that in some cases the dielectric strength of the product increases after exposure to certain temperatures and humidities. Type 72 is available in thicknesses of 3, 4, 6 and 9 mils in tapes, cut sheets and rolls.

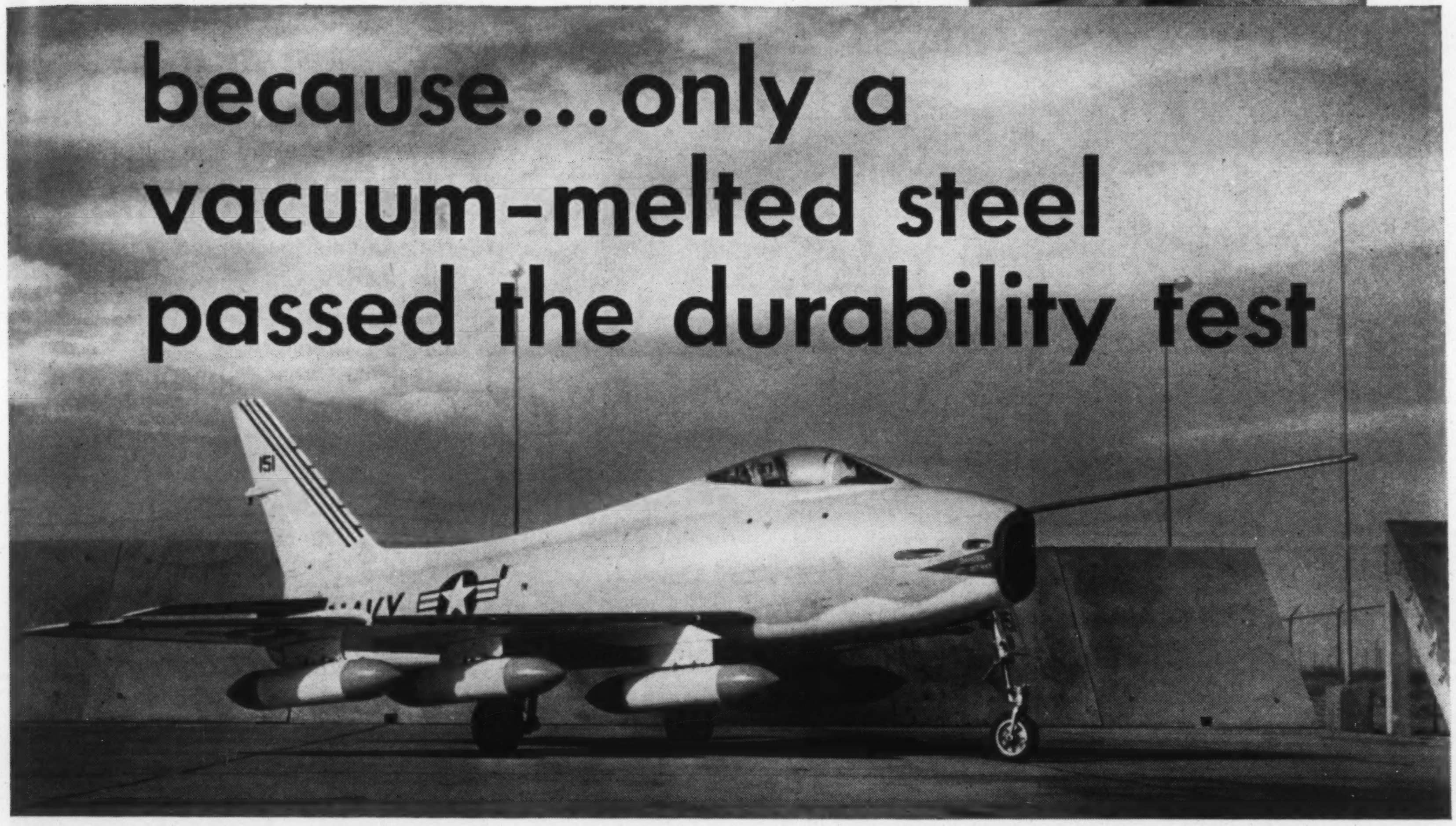
The epoxy-treated asbestos insulations are recommended for use as slot liners; phase separators; and layer, barrier and wrapper insulation in motors, generators, transformers and resistance devices.

Reinforced Acrylic for Vacuum Forming

There is at present no formable plastics sheet that combines good weather resistance with high impact strength, craze resistance and nailability. Also, there is no high impact material that has the

The Ruffe, Inc. combination bomb rack and rocket launcher employs a hook pivot pin made from vacuum-melted steel

Why?



because...only a vacuum-melted steel passed the durability test

The hook pivot pin in the Aero 15B bomb rack and rocket launcher must be highly resistant to fatigue. To test this property, the pin must undergo 4½ hours of destructive vibration tests. It is subjected to vibration in each of three axes in turn with a frequency of 50 c.p.s. and a total excursion of 0.06 inches while loaded with a 500 pound store. This is no minor point, as the 500 pound store under these vibration conditions exerts a damaging and fatigue effect considerably more than a 500 pound load under any other test condition.

Air-melted steel did not stand up under this rigorous testing. But Ferrovac vacuum-melted 4340 steel emerged without apparent damage.

A vacuum-melted metal with such improved durability and strength may be just what you need when other types can't measure up to your rigid specifications. A VMC engineer will gladly help you explore this possibility. Thus the full technical resources of the first and largest producer of vacuum-induction melted metals will be placed willingly at your disposal. Write—describing your problem—in detail—to *Vacuum Metals Corporation, Division of Crucible Steel Company of America, P. O. Box 977, Syracuse 1, N. Y.*

Vacuum-melting is adding new performance to these metals. Do you have an application that may benefit from their use?

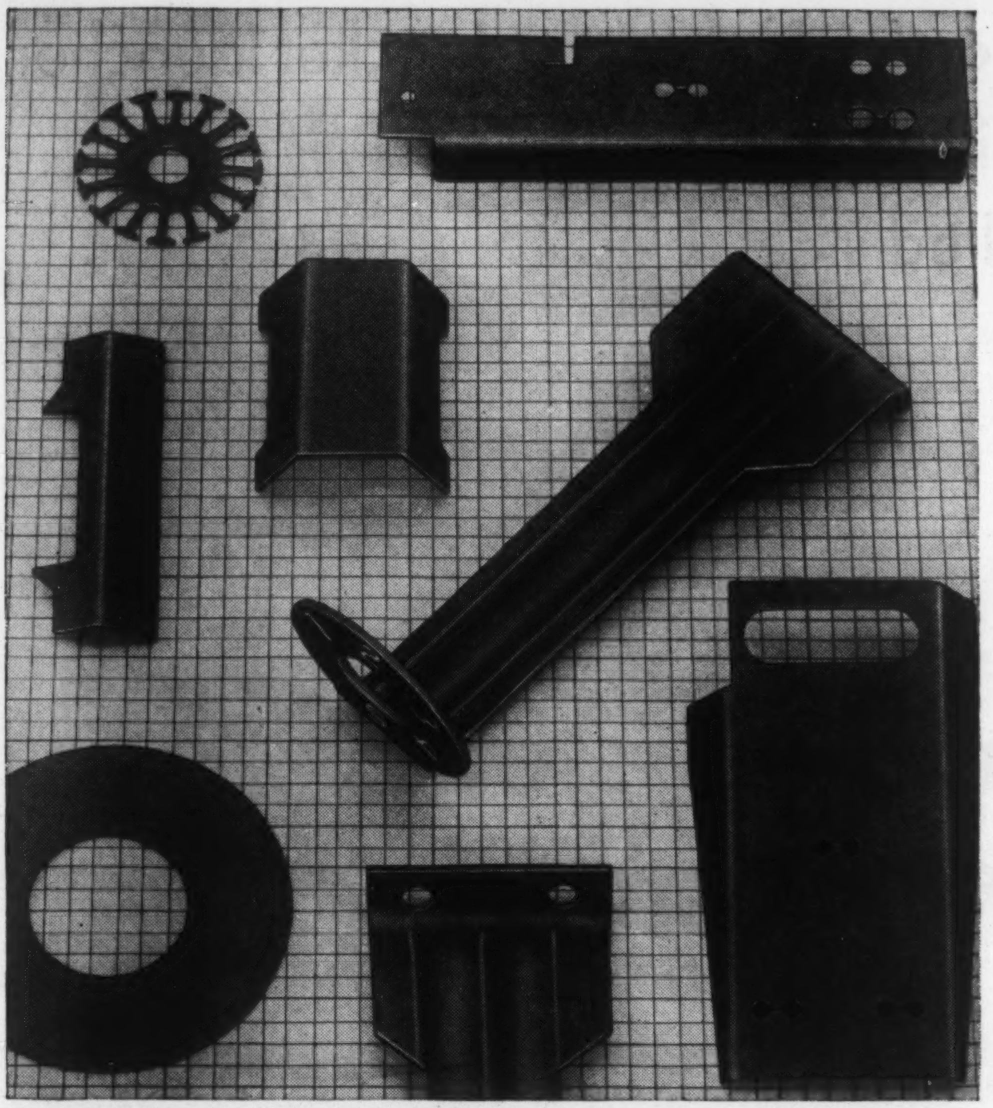
- High temperature alloys
- High strength alloy steels
- Low alloy steels for springs
- Nuclear reactor materials
- Special nonferrous alloys
- Alloys for investment castings
- Bearing steels
- Tool steels
- Stainless steels
- Hard facing alloys
- Electronic alloys
- Soft Magnetic alloys

VMC®

VACUUM METALS CORPORATION

Division of Crucible Steel Company of America

For more information, turn to Reader Service card, circle No. 364



problem: **reduce cost of fibrous insulating parts without sacrificing quality**

solution: **Duroid 700**

Right now DUROID 700 offers a cost advantage over equivalent fibrous insulating materials. But that is only one reason for using this extremely tough, homogenous insulation. It offers excellent arc resistance and dry dielectric strength. Furthermore it retains its dielectric strength to a large extent under high humidity. It also affords fabricating advantages — in that it can be formed as well as blanked, scored, slit and sheared.

For improved insulation at lower cost, specify U. L. listed Duroid 700. For an end cost that is still lower, have Rogers fabricate your finished parts.

For technical data, please write Dept. M.

TEST VALUES

Thickness (in.)	0.062	Bursting Strength (psi)	2000
Density (gr/cc)	1.20	Water Absorption (%-24 hrs.)	50
Weight (gr/cu. in.)	20.9	Ash (%)	0.50
Tensile (lengthwise-psi)	23000	Dielectric Strength (VPM-BD)	500
Tensile (crosswise-psi)	7000	Dielectric Strength (VPM@7%MC)	300
Flexural (lengthwise-psi)	26000	Arc Resistance (sec.)	75-100
Flexural (crosswise-psi)	15000	Rockwell Hardness (R Scale)	85
Compression Strength (psi)	41000	Oil Resistance	Good

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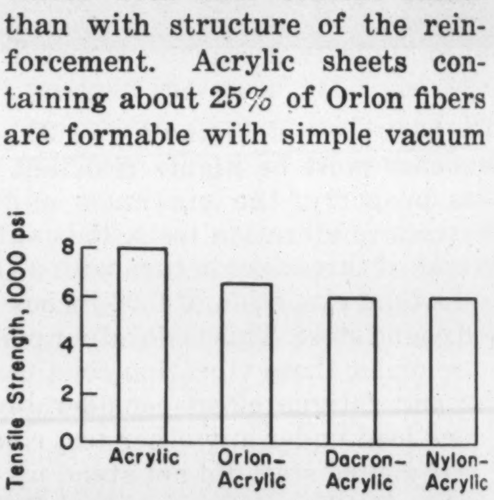
strength and stiffness of the so-called "hard" polymers, such as the acrylics and polystyrene.

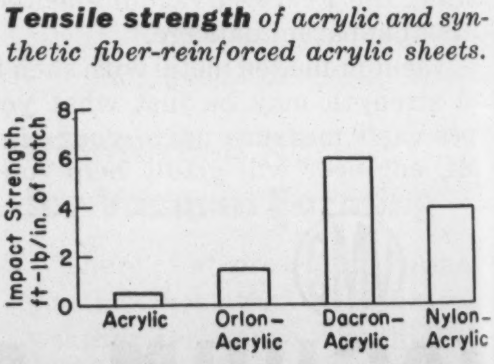
Recently, Dale E. Jackson and Don A. Moore, E. I. du Pont de Nemours & Co., decided to investigate Orlon, Dacron and nylon fibers in the form of needled batts as reinforcing agents for acrylic sheets. The needled batt structure, now commercially available, consists of random nonwoven fibers 2 to 4 in. long. The fibers are held together mechanically as a result of a needle punching operation. Other structures, such as woven cloth and synthetic fiber papers, were also investigated. Polymethyl acrylate was chosen as the matrix because of its excellent weatherability.

Fiber content important

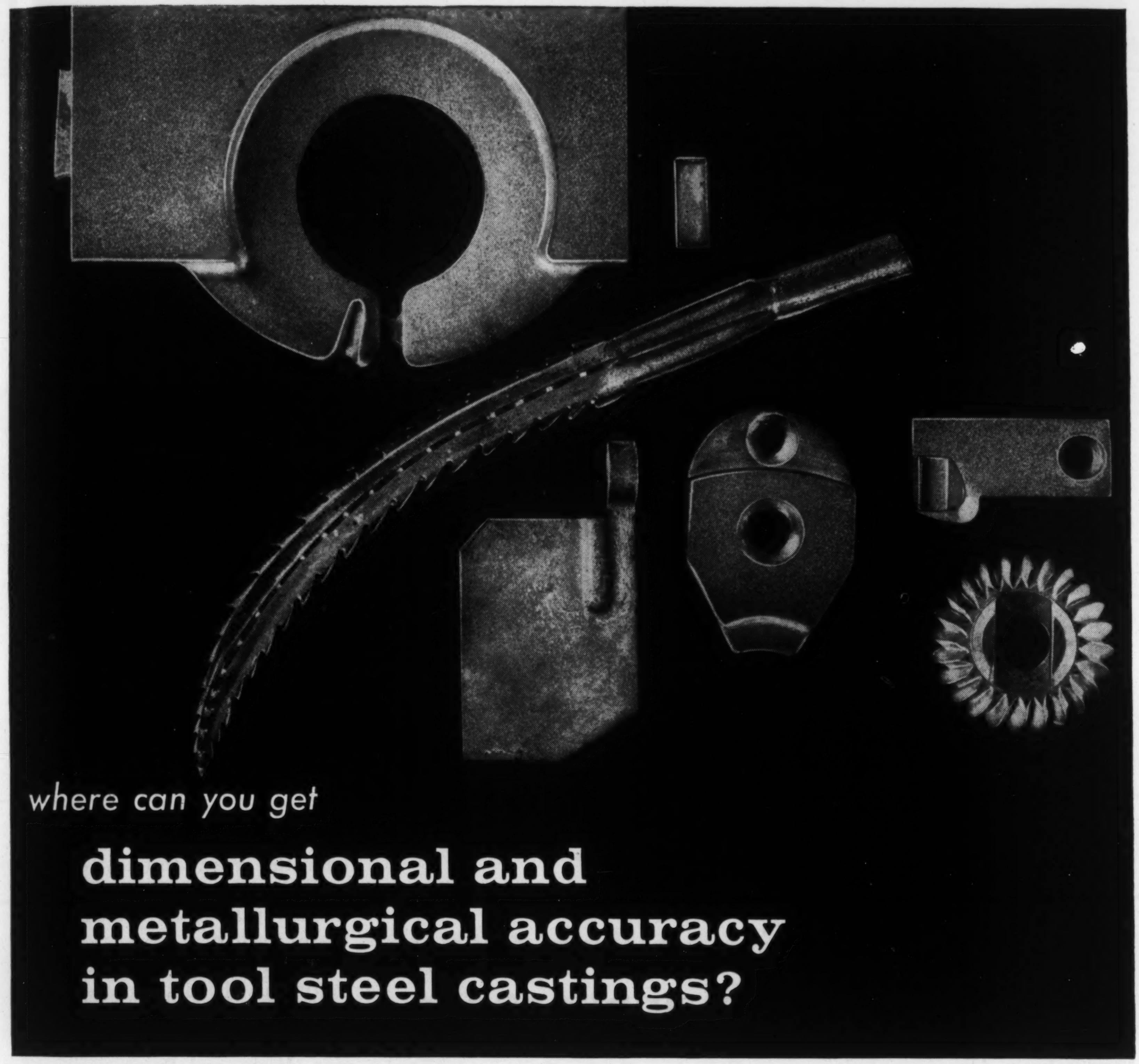
The investigators, who presented the results of their findings at the 1957 Technical Conference of the Society of Plastics Engineers, found that physical properties, particularly impact strength, of the reinforced sheets varies with fiber content rather than with structure of the reinforcement. Acrylic sheets containing about 25% of Orlon fibers are formable with simple vacuum



Tensile strength *of acrylic and synthetic fiber-reinforced acrylic sheets.*



Impact strength *of acrylic and synthetic fiber-reinforced acrylic sheets.*



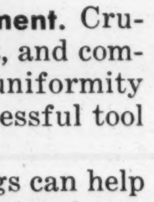
The quality of tool steel castings depends heavily on metallurgical control and foundry techniques which can be acquired only through long experience in handling tool steels. That's why it will pay you to get your castings directly from Crucible, largest and leading producer of tool steels.

Only Crucible can furnish precision castings in Ketos, Rexalloy, Rex M-2, Rex AA, Airkool, HYCC and Airdi 150—tool steels that solve wear, abrasion and temperature problems when ordinary alloys fail.

Crucible Accumet® Precision Investment Tool Steel Castings are regularly produced with a tolerance of ±.005″ (and even ±.002″ or ±.003″) and a surface finish of 125 RMS to 62 RMS . . . and in almost any shape or configuration.

Uniformity in response to heat treatment. Crucible quality control, from heat to heat, and complete inspection facilities ensure the uniformity in hardenability so necessary for successful tool steel castings.

Crucible Accumet Tool Steel Castings can help you reduce costs and improve product performance. Consider Crucible's extensive facilities and experience when you need either investment or sand castings. Write for free booklet to: *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pennsylvania.*



CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

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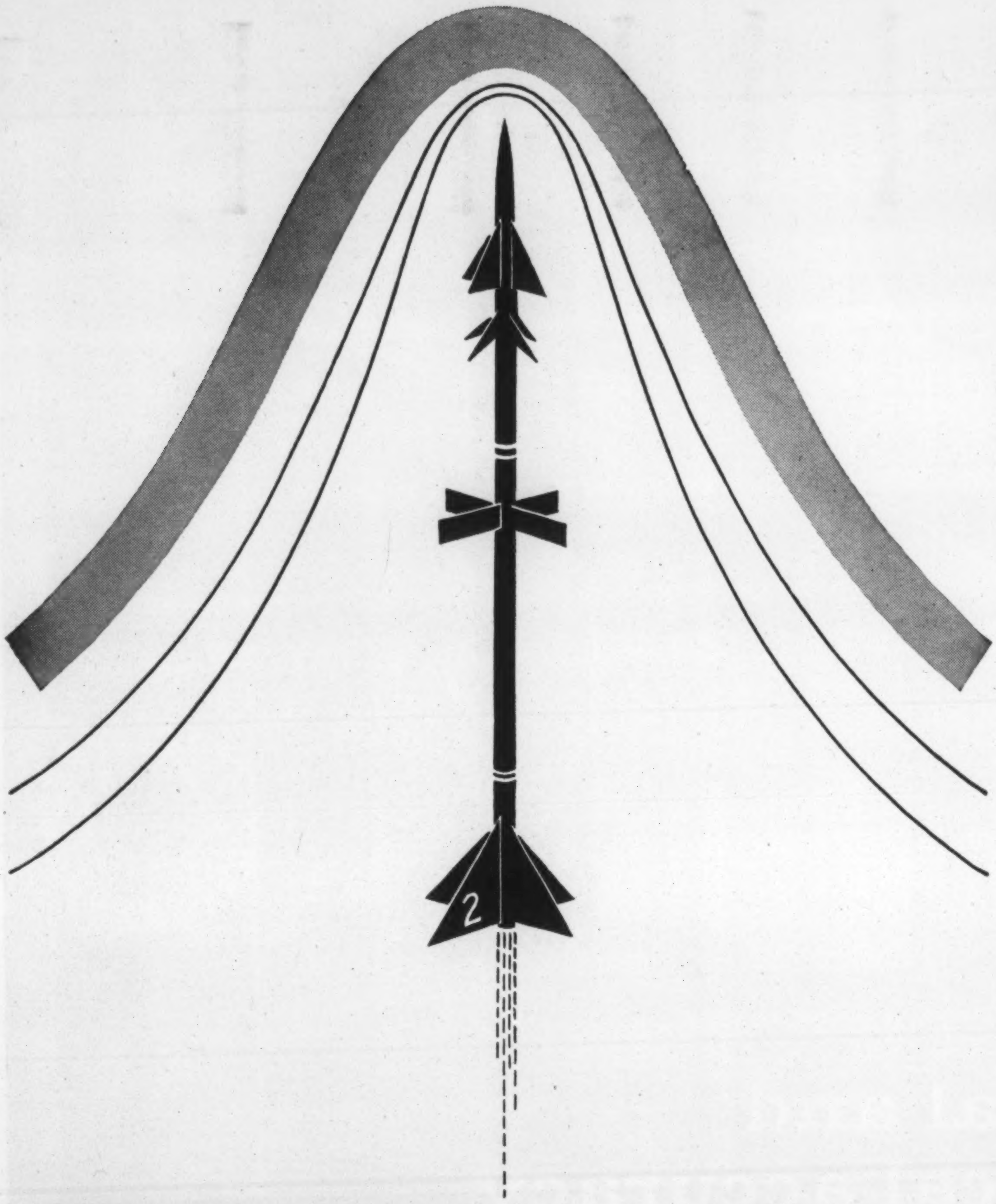

now magnesium castings for high temperature applications

Now you can enjoy the high strength-weight ratio of magnesium at high temperatures. Alloys now being cast by Rolle have the tensile strength and creep resistance modern jets and missiles demand . . . even at temperatures above 600F.

Developed by Magnesium Elektron Ltd., these rare-earth magnesium alloys were pioneered in this country by Rolle personnel. And in the hands of Rolle foundry engineers, the published specifications of the alloys are being realized to the utmost in casting after casting.

As a specialist in the sand, permanent mold, shell, and investment casting of the light metals, Rolle can offer you unrivalled experience from design through pouring and testing . . . whether you need creep resistance above 600F or not. Take advantage of that experience by bringing your casting problems to Rolle. You'll be assured of the best possible casting in the one alloy that meets all your needs, and at the same time, you'll save time, trouble, *and* expense.

FREE 57-PAGE ENGINEERING MANUAL *helps you design and specify aluminum and magnesium castings. Available on letterhead request. Write for your personal copy.*

there is a difference in Rolle laboratory controlled castings

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techniques. However, ease of formability of acrylic sheets decreases with increasing Orlon fiber content. The investigators recommend the use of matched molds in forming acrylic sheets containing more than 25% of Orlon fibers.

Dacron and nylon-reinforced acrylic sheets showed much higher impact strengths than Orlon-reinforced acrylic sheets.

Plastics Foam Used in Metal, Wood Panels

Foamed polyethylene-insulated panels of aluminum, wood and glass are commercially available from Aluminum Co. of America, 1501 Alcoa Bldg., Pittsburgh 19, Pa. Alcoa says it hopes to be in full scale production of the panels later this year. Initially, the insulated panels will be sold in widths up to 48 in. and in thicknesses up to 6 in.

The panels are made with a new continuous bonding process developed jointly by Fred Robinson, of Robinson Industries, Inc., Coleman, Mich., and Ralph Stolle, of Stolle Corp., Cincinnati, Ohio. Alcoa says the insulated panels should find use in the refrigeration, transportation, appliance and marine industries.

Triacetate Fibers Can Be Made Anti-Static

Development of a process that imparts permanent anti-static properties to triacetate type synthetic fibers was announced recently by Celanese Corp. of America, 180 Madison Ave., New York 16, N. Y. The process creates a skin of cotton-like cellulose around each synthetic fiber filament. This skin, constituting about 2% of the total fiber, is an integral part of the fiber and, according to Cela-

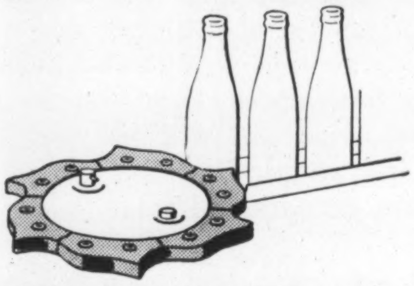
TAYLOR
Laminated Plastics
Vulcanized Fibre

Shop Talk

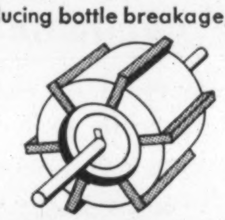
TAYLOR FIBRE CO.
Plants in Norristown, Pa. and La Verne, Calif.

PHENOLIC—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • COPPER-CLAD LAMINATES • VULCANIZED FIBRE

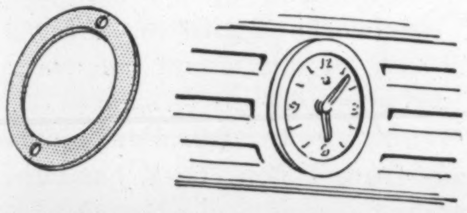
Tips for designers



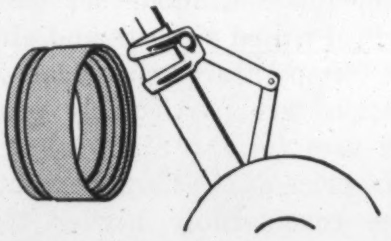
Indexing cams to position bottles under filling machines are made of Taylor Grade CEF phenolic laminate . . . replacing metal cams, they save money by reducing bottle breakage, avoiding rust.



Gas pump impeller unit is fabricated of Taylor Grade LE-6 phenolic laminate . . . economical, light-weight, wear-resistant . . . chosen because of strength, stability.



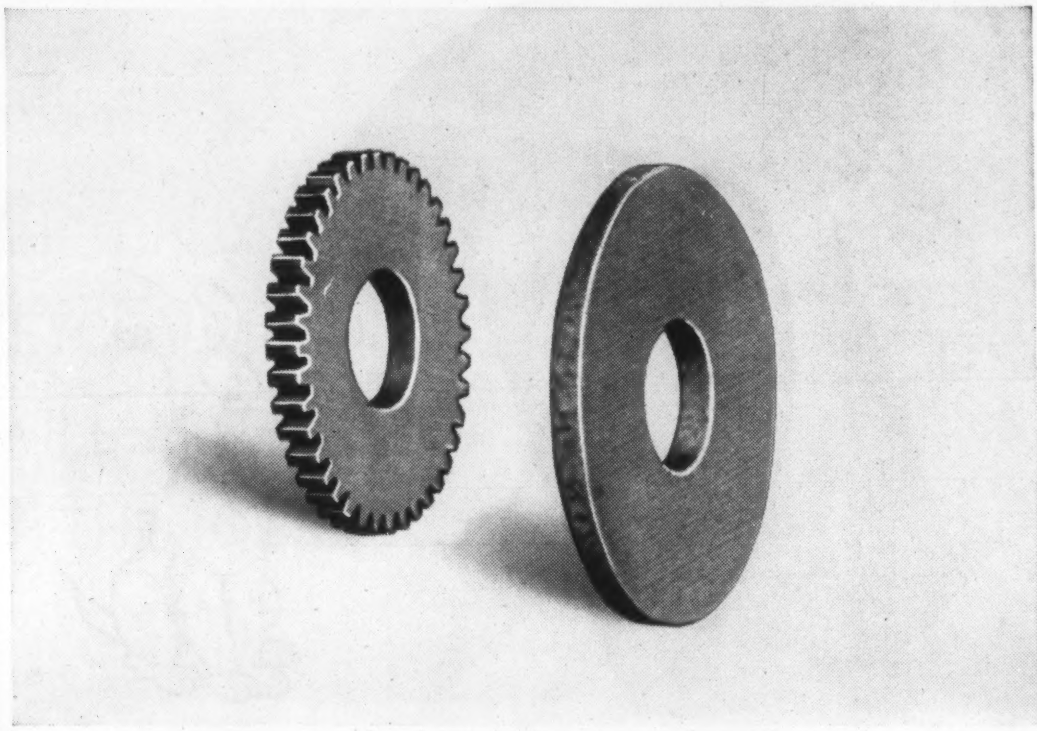
Automobile clock is securely and economically mounted on inside surface of metal dashboard, with a spacer fabricated from Taylor vulcanized fibre.



Aircraft landing gear bearings are fabricated of Taylor Grade LE-6 cotton base phenolic laminate to meet requirements of dimensional stability, wear resistance and low moisture absorption.

TAYLOR'S NEW
COPPER-CLAD LAMINATE
Cu-246

...is now available for your volume production of printed circuits. High purity rolled copper surface is adaptable for all circuit production methods. **Cu-246** is produced in all standard sheet sizes...in thicknesses from .020″ to .250″.



Special purpose gear is fabricated of Taylor Grade CEF phenolic laminate for Hadley Gear Mfg. Co. Taylor punches the gear blank to an I.D. tolerance of ± .001″ . . . material was selected for its excellent punchability, good machineability, moisture resistance and impact strength.

Taylor delivers precision parts

. . . geared to your production schedule

The inside diameter of this gear blank was punched to a tolerance of ± .001″ by Taylor's Fabrication Division—an example of the close tolerances which Taylor can meet. Taylor has special techniques and facilities for handling this type of work—acquired through years of experience in fabricating all kinds of laminates.

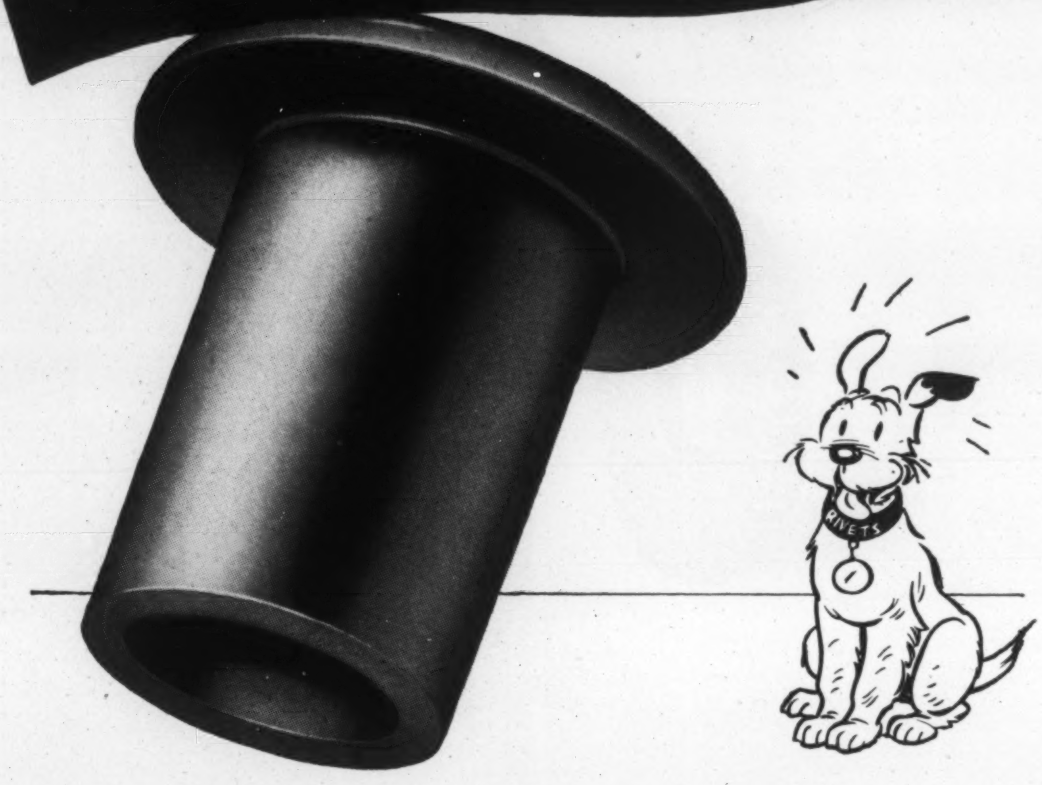
Taylor Grade CEF phenolic laminate was selected as the material for the gear blank—to take advantage of this laminate's excellent punchability and machineability as well as its moisture resistance and impact strength.

You can put Taylor's facilities and techniques to work improving your product. Taylor can deliver precision parts, such as this gear blank, fabricated to your most exacting specifications . . . geared to meet your production schedule.

When you have a problem of material selection or close-tolerance fabrication, or product design, check with Taylor. Chances are that Taylor's staff of home and field office specialists can help you in any or all of these essentials to a good product. Call or write your nearest Taylor sales office for a discussion of your requirements.

For more information, turn to Reader Service card, circle No. 465

Back of a Chicago Rivet
Is an Organization That Really Serves



The RIGHT rivet, plus the RIGHT riveting machine will produce a fastened assembly at the RIGHT low cost

The correct combination of rivet and machine requires expert knowledge available to you through Chicago Rivet engineers.

Anticipated production, type of materials to be fastened, assembly shape and its expected service life are factors to be considered. Decisions must be made on a rivet metal or alloy. Type and size of rivet, shape of head and shank, depth of tubular section must be all determined. Are indexing fixtures and multiple setters indicated? Can a standard rather than a special rivet be used? These are the type of questions Chicago Rivet Engineers are daily answering for industry. Their recommendations are available to you without cost. We suggest you send a blueprint or sample assembly with your inquiry.

There are Chicago Rivet Machines that will set
1
2
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6
Tubular or Split Rivets At a Time

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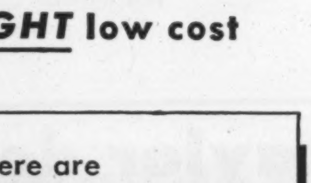
FOR YOUR FILES
Rivet catalog describing 1388 standard tubular and split rivets and 26 single and multiple automatic rivet setters.



For more information, turn to Reader Service card, circle No. 552

nese, cannot be removed by washing.

The new process uses inexpensive chemicals and can be used with conventional dyeing and finishing equipment. It is applicable only to Celanese Corp.'s triacetate fiber, Arnel, and will not work on other synthetic fibers such as polyesters, acrylics and nylon.

New Type Teflon Film May Be Available Soon

Film made from an extrudable grade Teflon resin called 100-X perfluorocarbon (see MATERIALS & METHODS, Nov '56, p 162) is now being evaluated by E. I. du Pont de Nemours & Co. The company says sample quantities of the film will be available upon completion of semiworks facilities. Actual full-scale production of the resin is not expected until 1959.

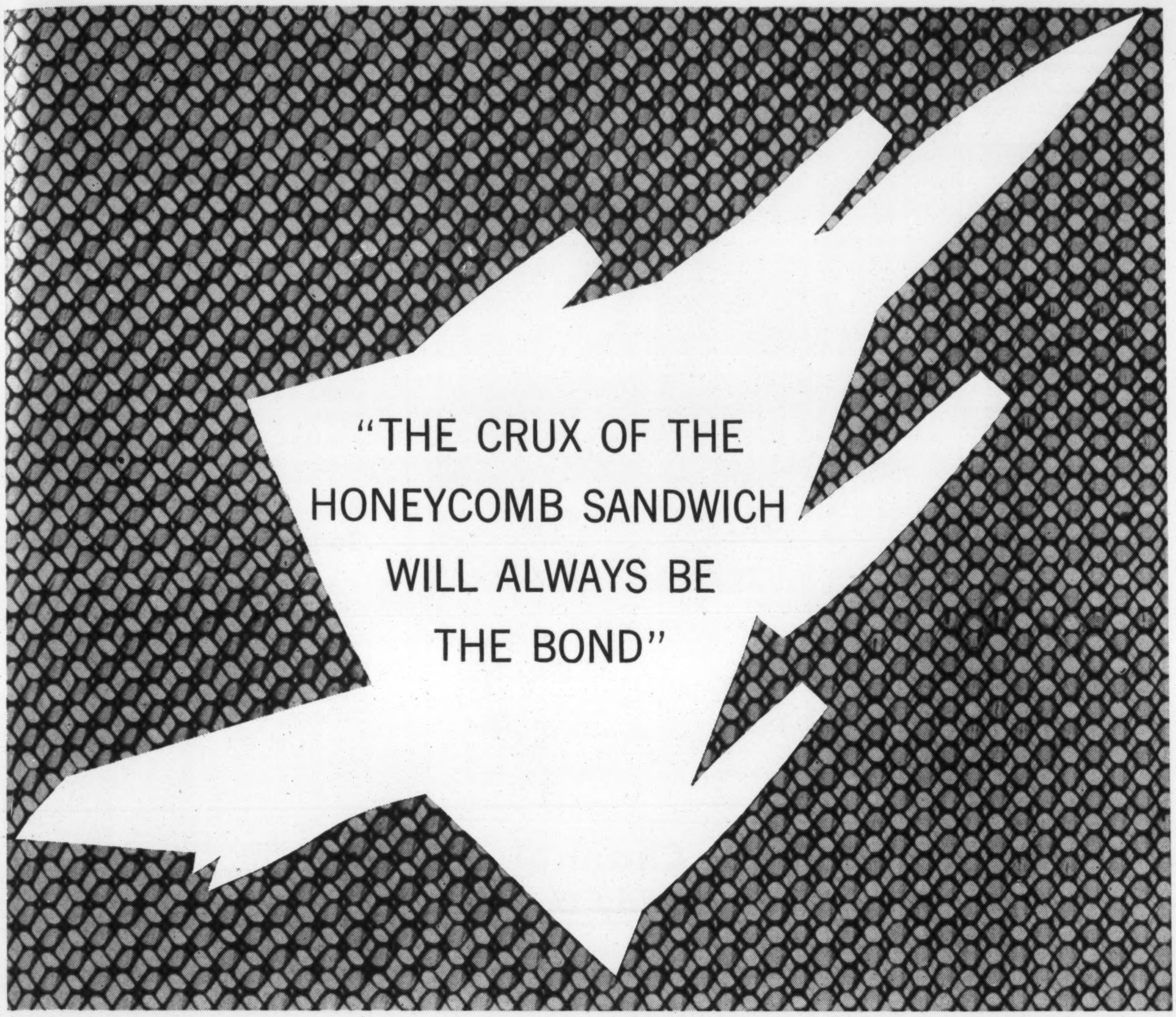
According to Du Pont, film made from Teflon 100-X has outstanding electrical insulating characteristics, particularly at high temperatures; the film is capable of continuous service at 400 F. Printed circuits and other high temperature electrical applications are particularly promising uses for the film.

The price of the film is expected to be considerably higher than that of polyester, cellophane and cellulose acetate films.

Flat Aluminum Wire Is Rounded on Edges

Round edge, flattened aluminum wires, made in thicknesses ranging from 0.020 to 0.187 in. and in widths from 0.063 to 1.0 in., are now commercially available from Kaiser Aluminum & Chemical Sales, Inc., 919 N. Michigan Ave., Chicago 11.

The wire is recommended for



*B-58 bomber designed and built by the Convair Division of General Dynamics Corporation, Fort Worth, Texas.

This is a direct quote from a recent article on honeycomb structures in *Aeronautical Purchasing* magazine. It states exactly what authorities in the field of supersonic speeds already know, and clearly points up the aims and activities of Handy & Harman in this critical and challenging field.

One of the most significant applications of the honeycomb sandwich can be found in the United States Air Force new supersonic bomber, the B-58.* Elements of this "missile with a man in it" are made of high-strength stainless steel honeycomb sandwich, *bonded* with Handy & Harman special silver brazing alloys – a method which permits honeycomb assemblies of virtually any size.

The honeycomb principle needs no further testimonial. Indeed, the problems it solves and the obstacles it overcomes *now* can mean only that its future is immensely promising. Work with all kinds of materials; metals, ceramics, plastics, paper, etc., is now in progress to further increase its present great values.

Handy & Harman, with its knowledge and facilities in the field of joining metals, can be of great help to you in many of these honeycomb sandwich research areas. Many of the developments in silver alloy brazing, heating methods, production techniques and the formulation of special alloys for special needs, were originated by Handy & Harman. Your efforts in devising new methods in metal joining and in meeting present bonding needs can be helped, in large measure, when you call on Handy & Harman.

B-58 engine nacelle section. Stainless steel honeycomb structure whose light weight is evident. Its strength and aerodynamic qualities are attested to in flight in the world's fastest jet bomber.

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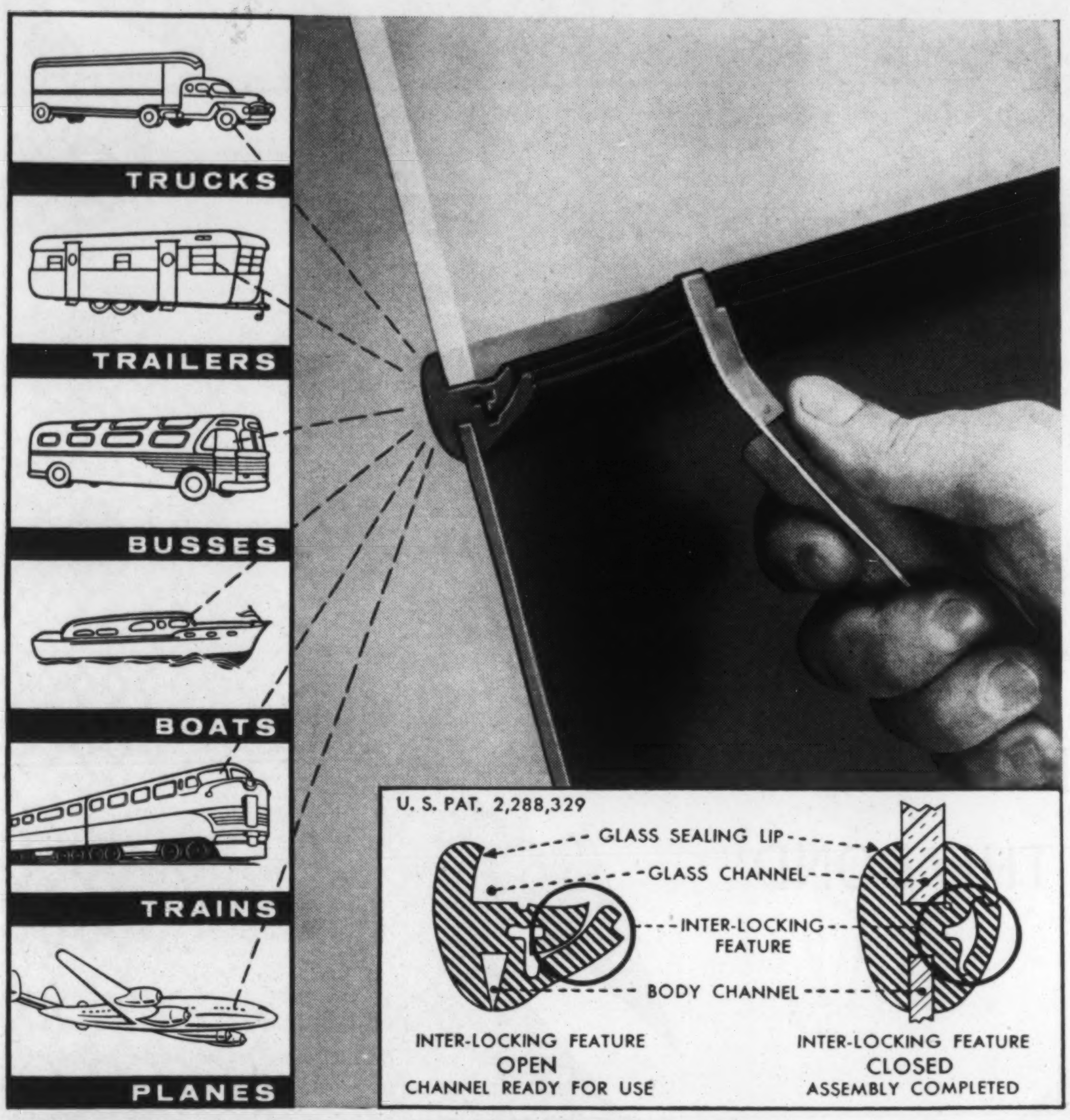
TRUCKS
TRAILERS
BUSSES
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PLANES
U. S. PAT. 2,288,329
GLASS SEALING LIP
GLASS CHANNEL
INTER-LOCKING FEATURE
BODY CHANNEL
INTER-LOCKING FEATURE OPEN CHANNEL READY FOR USE
INTER-LOCKING FEATURE CLOSED ASSEMBLY COMPLETED

Self-Locking Rubber Channel for Mounting Glass in Body Panels

Its *one-piece* design locks and seals in one operation. No extra locking-strip needed. It's the faster, simpler method for mounting glass in any type body panel—truck, trailer, bus, boat, train, plane, etc.

Extruded with inter-locking feature at direct right angle to body, the Continental Channel permits unhampered insertion of glass. Locking tongue is pressed into its matching groove which forces the lips against *both* the glass and body panel—a more positive seal with exceptional push-out pressure.

Compounded for maximum weather resistance and extra long life. Close durometer tolerances are held for uniformly tight seal against moisture and surest possible locking. These rubber channels can be positioned first on *either* glass or body panel. All details are shown in illustrated brochure gladly sent on request.

Ordered and re-ordered by the most prominent body builders, this Self-Locking Channel is another example of the creative thinking and ingenuity behind rubber parts by Continental. When you need rubber parts to do a specific job, call a rubber specialist *during the planning stage.* This often makes for economy as well as better end results. Call Continental—rubber specialists since 1903.

Engineering catalog.

In addition to custom-made parts, Continental offers an extensive line of standard grommets, bushings, bumpers, rings and extruded shapes. Hundreds of these are shown in the No. 100 Engineering Catalog. Send for a copy or refer to it in Sweet's Catalog for Product Designers.

Another achievement in **RUBBER**
engineered by **CONTINENTAL**

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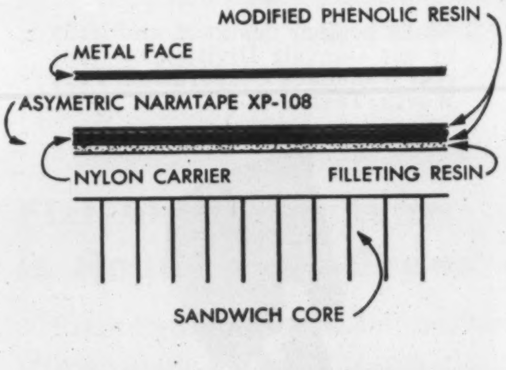
For more information, turn to Reader Service card, circle No. 449

use in such electrical items as primary and secondary transformer windings, current limiting reactors, welding transformers, d.c. generator commutator windings, and armor for cable and magnets. Other uses include ornamental grillwork and zippers.

Adhesive Designed for Sandwich Constructions

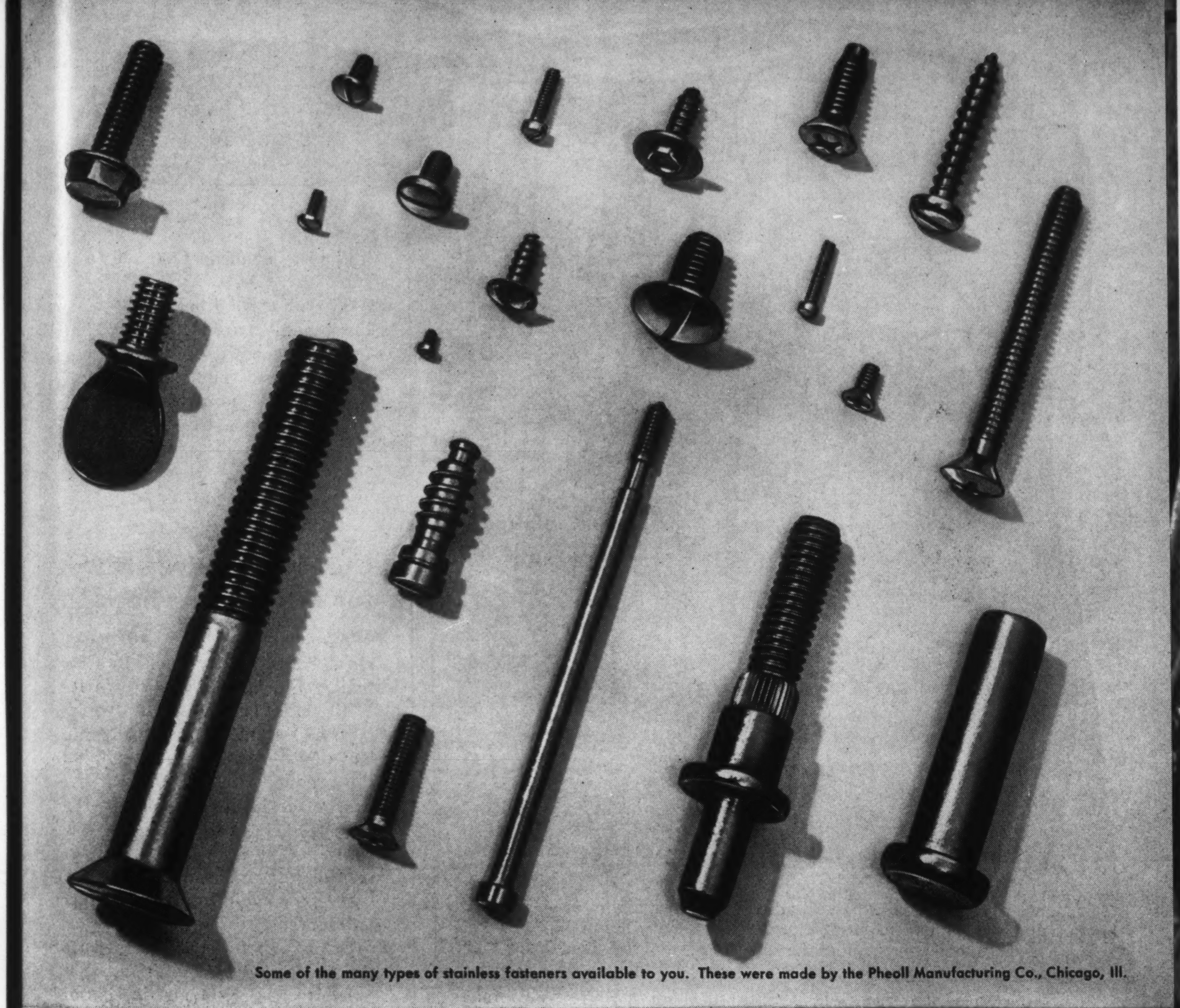
A new adhesive, designed specifically to eliminate the need for core priming in aircraft and missile sandwich component fabrication, has been developed by Narmco Resins & Coatings Co., 600 Victoria St., Costa Mesa, Calif.

Trade named Narmtape XP-108, the adhesive consists of a nylon carrier impregnated with a modified phenolic resin and over-coated on one surface with a highly mobile filleting resin. According to the producer, the addition of the filleting resin eliminates one of the most time-consuming steps in the fabrication of a wide variety of aircraft missile structures of bonded sandwich design. Previously, it was necessary to prime a metallic sandwich core to obtain proper adhesive filleting action, then air dry the core for 2 or 3


MODIFIED PHENOLIC RESIN
METAL FACE
ASYMETRIC NARMTAPE XP-108
NYLON CARRIER
FILLETING RESIN
SANDWICH CORE
METAL FACE
NYLON CARRIER
FILLETING RESIN
SANDWICH CORE

Filleting action *of new adhesive in aircraft and missile sandwich component bonding.*

For more information, circle No. 374 ➤



Some of the many types of stainless fasteners available to you. These were made by the Pheoll Manufacturing Co., Chicago, Ill.

How stainless steel fasteners make a better product at lower cost

Performance and appearance get a boost when you use stainless steel fasteners. For stainless resists rust, heat and corrosion. It keeps its good looks for a lifetime. Stainless-fastened products won't be marred by unsightly rust streaks—and they can be dis-assembled and assembled quickly and easily even after years of all-weather service.

Stainless helps keep production costs down. Work goes smoothly, for fastener heads of high-strength stainless are less apt to burr or nick. And there's no plating on stainless for a careless tool to chip or scrape away.

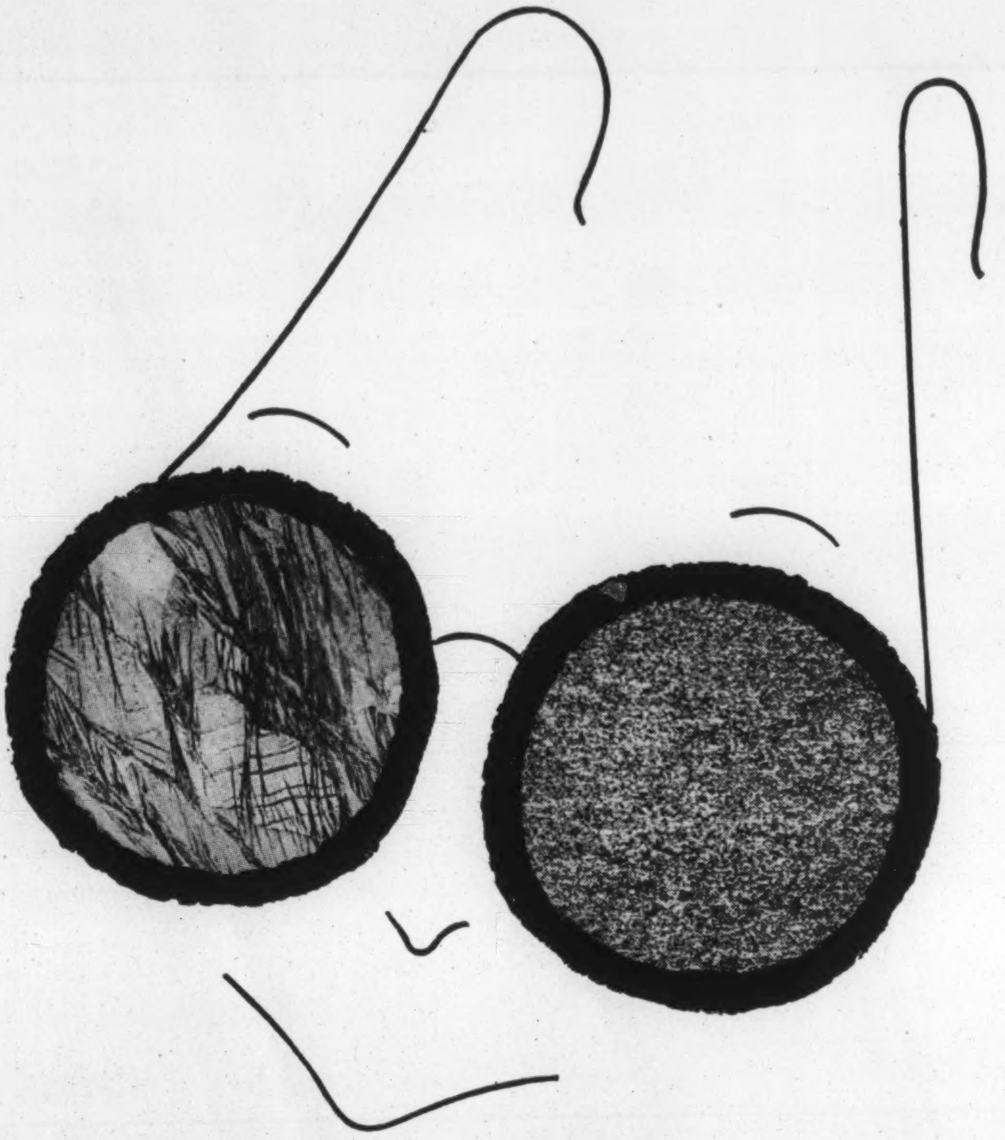
You cut tooling costs, too. For now stainless fasteners are promptly available in just about *any* size or description—and in any of the 200, 300, or 400 Rezistal stainless series. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

PRODUCTION MEN: If you use stainless steel cold heading wire, Crucible can fill your needs quickly and dependably. It is regularly supplied in all diameters and standard grades, and in a variety of finishes. For more information write for your free copy of the 32-page booklet, "Rezistal Stainless Steel Wire."

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.



You can see the difference

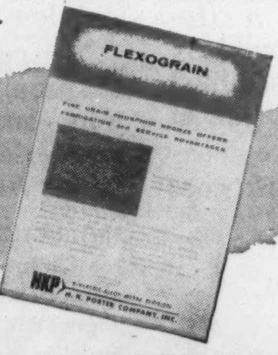
. . . not with the naked eye, we'll admit . . . nor even with bifocals, but put a polished and etched sample of our new FLEXOGRAIN phosphor bronze under the revealing eye of the microscope and compare it with phosphor bronze strip generally available.

The scientifically controlled, fine grain structure of FLEXOGRAIN is great for severe bending and other complex forming operations . . . improves fatigue resistance, surface finish and ductility . . . and cuts costly fabrication rejects to a minimum.

At Riverside-Alloy we have always been keenly aware of the importance of grain size control in determining functional and fabrication properties of our alloys. We have been supplying fine grain phosphor bronze strip for special applications for over 20 years. Now, with our recently expanded, modern facilities, we can supply production quantities to meet your needs.

For detailed information write to Riverside-Alloy Metal Division, H. K. Porter Company, Inc., Riverside, N. J.

Send today for Technical Bulletin T-4.



ALLOY METAL WIRE
Prospect Park, Pa.

RIVERSIDE METAL
Riverside, N.J.

PRENTISS WIRE MILLS
Holyoke, Mass.

H. K. PORTER COMPANY, INC.
RIVERSIDE-ALLOY METAL DIVISION

For more information, turn to Reader Service card, circle No. 537

hr before bonding the face to the core.

The adhesive, in addition to having good filleting action, is claimed to have good peel, tensile, compressive and flexural strengths. The adhesive is also said to have good resistance to aircraft fuels, salt spray and commercial solvents.

Chromized Steel Sheet for Hot Applications

A chromized SAE 1010 steel sheet has been developed by Chromalloy Corp., 450 Tarrytown Rd., White Plains, N. Y., to replace type 430 stainless steel in a number of applications. According to the producer, the chromized sheet has better heat conductivity than type 430—a characteristic especially useful at high temperatures in reducing actual metal temperature and avoiding formation of hot spots.

Other advantages claimed for the sheet material are:

1. Its cost, 49¢ per lb, is said to be considerably less than that of type 430.
2. It can be easily bent, staked, drawn and welded without cracking.
3. The chromium skin is integral with the base metal and cannot be separated from it.
4. The chromium skin on the steel does not spall, peel, flake or chip after cold forming operations.

Improved Deadener Banishes Fire Hazard

An improved automotive undercoating has been developed to eliminate the fire and health hazards which often accompany the handling and use of these materials on the production line. Called No. 42 Deadener and pro-

He's Ready to Hammer Out Anything You Give Him

When this photograph was taken in the Bethlehem drop-forge shops, the operator was pounding out an order of steam-trap bodies. Right after he finished, there was another job waiting for him to handle. It bore no relation to steam-trap bodies, nor did the forgings he made in the several weeks that followed. No two jobs were alike.

A Bethlehem forge-shop man is prepared for all designs. He's ready for anything. Once in action, he makes those hammers and presses dance, and they dance to his tune. He's a man who knows his craft. That's one of the reasons why Bethlehem closed-die forgings are unexcelled anywhere. Other vital factors are quality steel, an alert metallurgical service, and first-class treating and inspection facilities. All of these Bethlehem has. Whenever you need closed-die forgings ranging from one to 250 lb, we suggest you call us. We'll cooperate fully.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by
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BETHLEHEM STEEL

BETHLEHEM STEEL

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TITLE.........................
COMPANY.........................
ADDRESS.........................
CITY.................. ZONE........ STATE..........

For more information, turn to Reader Service card, circle No. 451

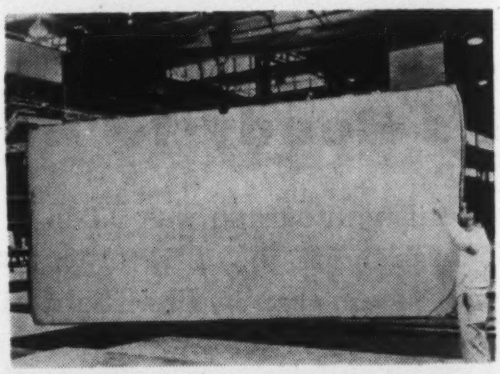
duced by Phillip Carey Mfg. Co., Lockland, Cincinnati 15, Ohio, the undercoating is said to be nonflammable, nontoxic, non-explosive and odorless. The undercoating is designed specifically for use on steel surfaces as a sound and vibration deadener and as an anticorrosive coating.

Three PVC Resins

Three new polyvinyl chloride resins are presently being marketed by Escambia Chemical Corp., 261 Madison Ave., New York 16. The resins are: PVC 1200, a low molecular weight resin; PVC 1225, an intermediate molecular weight resin; and PVC 1250, a high molecular weight resin. All three resins are said to have good heat and color stability.

PROPERTIES OF 1200 SERIES

	1200	1225	1250
Ten Str, psi.......	2670	2750	2960
Elong, %.........	280	300	340
Modulus(100%),psi	1870	1920	1940
Shore Hard.......	A 86	A 87	A 88



Stainless steel plate — Shown above is what is claimed to be the first 17-4 PH stainless steel plate ever rolled. Produced by G. O. Carlson, Inc., Thorndale, Pa., the plate weighs 3950 lb and measures 174 x 79 x 1 in. In order to produce the plate, it was necessary to maintain an even temperature from the time the ingot was poured to the final rolling operation.

HARSHAW *makes over* **1,000 CHEMICALS**
for more than **15,000** *customers in*
50 *varied industries throughout the world!*

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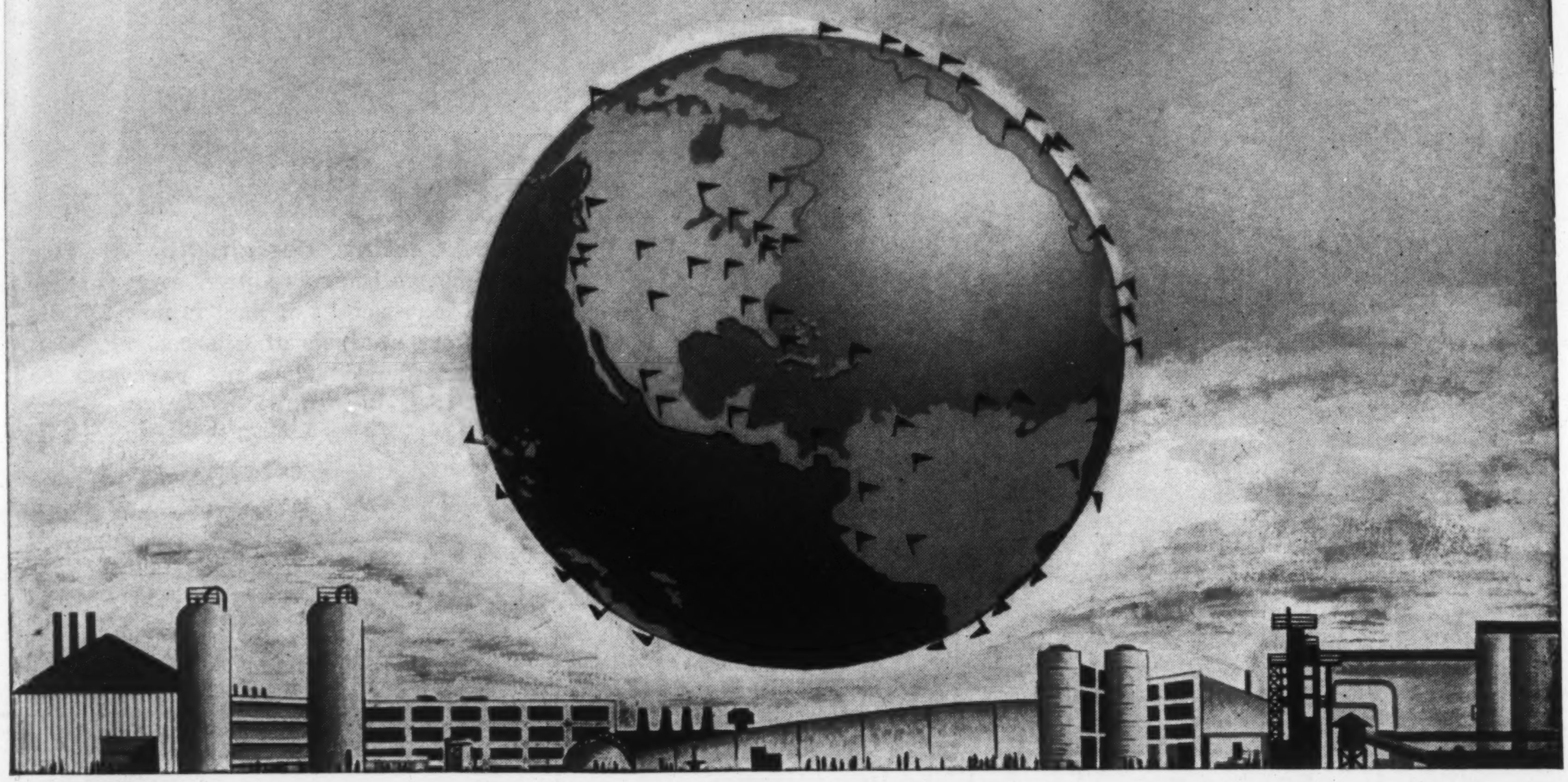

HARSHAW sells chemicals —thousands of them— for these and many other industries throughout the world

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- Engraving and Electrotyping
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- Food
- Glass
- Insecticide and Fungicide
- Laundry
- Leather
- Lithographing
- Linoleum and Floor Covering
- Lubricant
- Match
- Metallurgical
- Metal Working
- Oil Cloth
- Optical
- Paint, Varnish and Lacquer
- Paper
- Petroleum
- Pharmaceutical
- Photographic
- Porcelain Enamel
- Plastics
- Pottery
- Printing Ink
- Pyrotechnic
- Refractories
- Rubber
- Shade Cloth
- Soaps
- Textile
- Veterinary Remedies
- Welding Electrodes
- Wall Paper

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- Fluorides
- Glycerine
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- Synthetic Optical Crystals
- Agricultural Chemicals
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- Chemical Commodities

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FREE! This 16-page booklet lists the many chemicals available from Harshaw.

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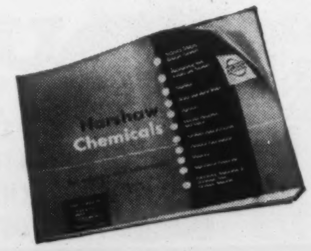

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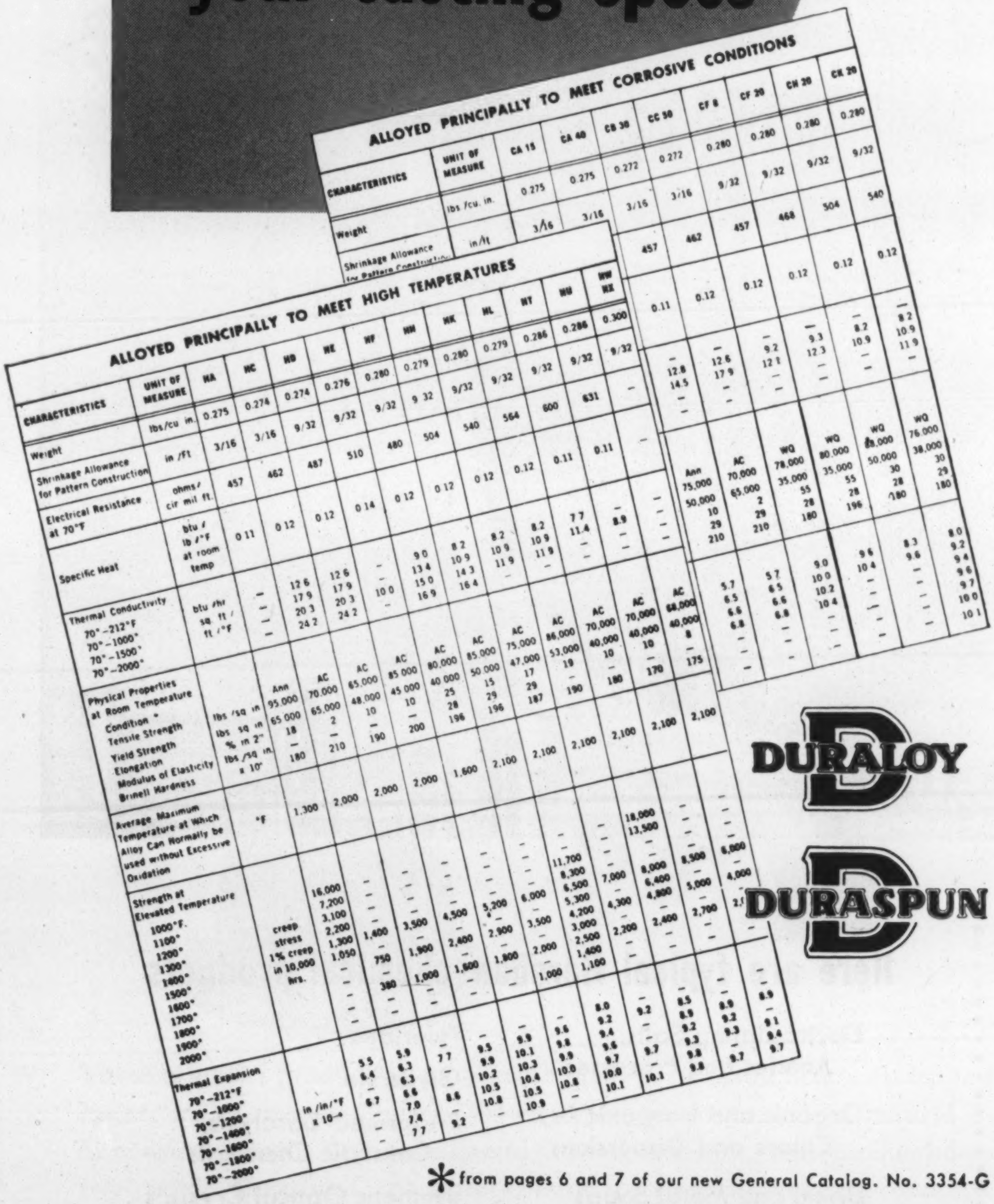
* TABLES to help you select the proper alloy for your casting specs



ALLOYED PRINCIPALLY TO MEET CORROSIVE CONDITIONS

CHARACTERISTICS	UNIT OF MEASURE	CA 15	CA 40	CB 30	CC 50	CF 8	CF 20	CH 20	CK 20
Weight	lbs /cu. in.	0.275	0.275	0.272	0.272	0.280	0.280	0.280	0.280
Shrinkage Allowance for Pattern Constructio	in/ft	3/16	3/16	3/16	3/16	9/32	9/32	9/32	9/32
				457	462	457	468	504	540
				0.11	0.12	0.12	0.12	0.12	0.12
				— 12.8 14.5 — —	— 12.6 17.9 — —	— 9.2 12.1 — —	— 9.3 12.3 — —	— 8.2 10.9 — —	— 8.2 10.9 11.9 —
				Ann 75,000 50,000 10 29 210	AC 70,000 65,000 2 29 210	WQ 78,000 35,000 55 28 180	WQ 80,000 35,000 55 28 196	WQ 88,000 50,000 30 28 180	WQ 76,000 38,000 30 29 180
				5.7 6.5 6.6 6.8 — — —	5.7 6.5 6.6 6.8 — — —	9.0 10.0 10.2 10.4 — — —	9.6 10.4 — — — — —	8.3 9.6 — — — — —	8.0 9.2 9.4 9.6 9.7 10.0 10.1

ALLOYED PRINCIPALLY TO MEET HIGH TEMPERATURES

CHARACTERISTICS	UNIT OF MEASURE	HA	HC	HD	HE	HF	HH	HK	HL	HT	HU	HW HX
Weight	lbs/cu in.	0.275	0.274	0.274	0.276	0.280	0.279	0.280	0.279	0.286	0.286	0.300
Shrinkage Allowance for Pattern Construction	in /ft	3/16	3/16	9/32	9/32	9/32	9 32	9/32	9/32	9/32	9/32	9/32
Electrical Resistance at 70°F	ohms/ cir mil ft.	457	462	487	510	480	504	540	564	600	631	—
Specific Heat	btu / lb /°F at room temp	0 11	0 12	0 12	0 14	0 12	0 12	0 12	0 12	0.11	0.11	—
Thermal Conductivity 70°–212°F 70°–1000° 70°–1500° 70°–2000°	btu /hr sq. ft / ft /°F	— — — —	12 6 17 9 20 3 24 2	12 6 17 9 20 3 24 2	— — 10 0 —	9 0 13 4 15 0 16 9	8 2 10 9 14 3 16 4	8 2 10 9 11 9 —	8.2 10 9 11 9 —	7 7 11.4 — —	— 8.9 — —	— — —
Physical Properties at Room Temperature Condition * Tensile Strength Yield Strength Elongation Modulus of Elasticity Brinell Hardness	lbs /sq in lbs sq in % in 2" lbs /sq in. x 10⁶	Ann 95,000 65,000 18 — 180	AC 70,000 65,000 2 — 210	AC 65,000 48,000 10 — 190	AC 85,000 45,000 10 — 200	AC 80,000 40,000 25 28 196	AC 85,000 50,000 15 29 196	AC 75,000 47,000 17 29 187	AC 86,000 53,000 19 — 190	AC 70,000 40,000 10 — 180	AC 70,000 40,000 10 — 170	AC 68,000 40,000 8 — 175
Average Maximum Temperature at Which Alloy Can Normally be used without Excessive Oxidation	°F	1,300	2,000	2,000	2,000	1,600	2,100	2,100	2,100	2,100	2,100	2,100
Strength at Elevated Temperature 1000°F. 1100° 1200° 1300° 1400° 1500° 1600° 1700° 1800° 1900° 2000°	creep stress 1% creep in 10,000 hrs.	16,000 7,200 3,100 2,200 1,300 1,050 — — — — —	— — — — 1,400 — 750 — 380 — —	— — — — 3,500 — 1,900 — 1,000 — —	— — — — 4,500 — 2,400 — 1,600 — —	— — — — 5,200 — 2,900 — 1,800 — —	— — — — 6,000 — 3,500 — 2,000 — 1,000	— — 11,700 8,300 6,500 5,300 4,200 3,000 2,500 1,400 1,100	— — — — 7,000 — 4,300 — 2,200 — —	18,000 13,500 — — 8,000 6,400 4,800 — 2,400 — —	— — — — 8,500 — 5,000 — 2,700 — —	6,000 — 4,000 — 2,[illegible] —
Thermal Expansion 70°–212°F 70°–1000° 70°–1200° 70°–1400° 70°–1600° 70°–1800° 70°–2000°	in /in/°F x 10⁻⁶	5.5 6.4 — 6.7 — — —	5.9 6.3 6.3 6.6 7.0 7.4 7.7	— 7.7 — — 8.6 — 9.2	— 9.5 9.9 10.2 10.5 10.8 —	— 9.9 10.1 10.3 10.4 10.5 10.9	— 9.6 9.8 9.9 10.0 10.8 —	8.0 9.2 9.4 9.6 9.7 10.0 10.1	— 9.2 — — 9.7 — 10.1	— 8.5 8.9 9.2 9.3 9.8 9.8	— — 8.9 9.2 9.3 — 9.7	— — 8.9 — 9.1 9.4 9.7

DURALOY

DURASPUN

* from pages 6 and 7 of our new General Catalog. No. 3354-G

— and there's lots more useful information about high alloy castings in our up-to-date catalog describing Duraloy Service. SEND FOR YOUR COPY.

As one of the pioneers in both static (1922) and centrifugal (1931) high alloy castings, we have a wealth of experience to focus on your high alloy casting problem. Send for our catalog, study it, and then let us help you get the best alloying combination to solve your corrosion, high temperature and/or abrasion problem.

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OFFICE AND PLANT: Scottdale, Pa.
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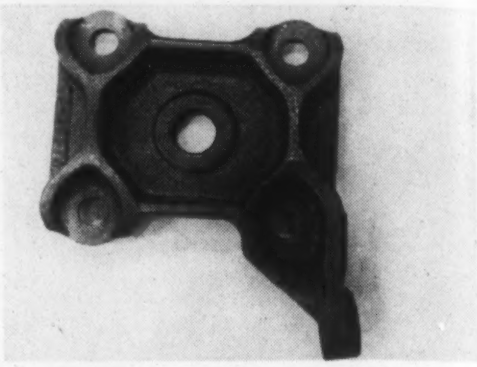
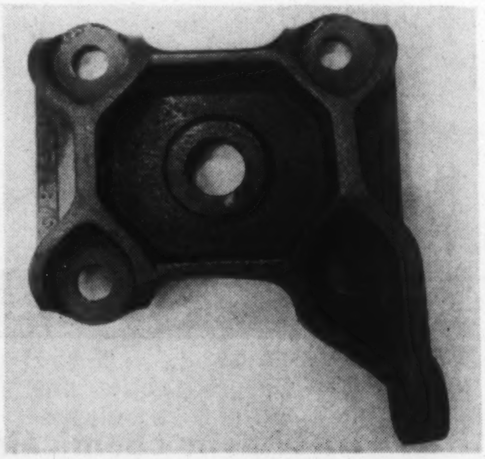
Bracket redesign—cont'd from p 12



6. Casting design No. 3. This time walls are reduced even further so that weight of part is now 2.75 lb. Stress analysis of this casting, however, showed that the part cracked at 15 ft-lb torque.



7. Casting design No. 4. The final casting, now weighing 2.90 lb (considerably below the original), was found under stress analysis to sustain nearly 3000 lb load at less than 0.30-in. deflection—almost 2200 lb above specifications.

Largest Radar Board Uses Acrylic Sheet

A single panel of cast acrylic, 30 ft long, 19 ft wide and ½ in. thick, is used in what is claimed to be the world's largest radar plotting board.

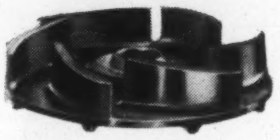
Designed and erected for the Air Defense Command by Brooks & Perkins, Inc., the plotting board was fabricated at the job site from eight 100 x 120-in. sheets—the largest thermoplastic sheets

RICHARDSON

IMPROVES molded auto parts

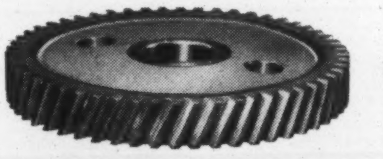
Each of the molded parts pictured at the right has specifications which call for special materials—often with unusual properties. All called for creative design. The volume production of these parts is proof of the thoroughness with which we approach your problems and the quality put into the finished product.

Send for the Richardson Molded Catalog or Glossary of Plastic Terms. There is no obligation. Write Dept. 27, 0000 Lake Street, Melrose Park, Illinois.



water pump impeller

Made of special moisture resistant phenolic. Withstands the extremes of high heat and intense cold, strong torque action, and corrosion and cavitation resulting from circulation in the car's cooling system.

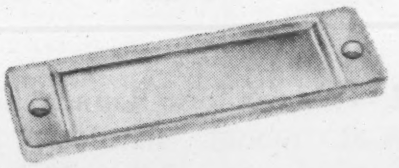


timing gear

Working from manufacturer's specifications, Richardson engineers developed a new material which resulted in excellent flexural strength in the web section and good bond in the laminate section—which permitted easy cutting of gear teeth with proper tooth strength. The change to plastic gears has made fabrication easy, operation is quieter, and gear life has been tripled!

radio antenna mast base

This part has good surface appearance, high impact strength, high dielectric strength, and is water and weather resistant. Material specified was black phenolic with an attractive high gloss finish.



dashboard light lens

Original part was a clear lens. Specification changes called for a translucent lens. Sandblasting the mold or the clear parts was rejected because it would add to the unit cost. Instead, Richardson engineers worked out a special light transmitting polystyrene lens which resulted in a 15% reduction of lens cost.

RICHARDSON
PLASTICS
LAMINATED and MOLDED

the RICHARDSON COMPANY

Founded in 1858

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Here's How

CHAMPION

Upset Forgings Give you a Better Product at Lower Cost

FOR SUCH PARTS AS:

- Valve Stems
- Pinion Gears
- Cluster Gears
- Boiler Braces
- Pipe Couplings
- Trunnion Shafts
- Chain Pins

MAXIMUM STRENGTH

When a metal blank is upset, it will flow into the upsetting die and the grain structure will be changed into a pattern of smooth curves that conform to the die shape, resulting in a product with equal or greater strength than that of the blank used.

MAXIMUM ECONOMY

The upset process is well suited to produce articles at or near the finished sizes; thereby reducing the amount of raw material needed. This saving, in material only, can run as high as 80%.

MATERIAL—We can form Rounds, Squares, Hexs, of steel, monel, stainless, bronze, hastalloy, etc. in sizes from 3/8" to 3" diameter.

For full details write for our Upset Forgings Bulletin.

THE CHAMPION RIVET COMPANY

CLEVELAND 5, OHIO

EAST CHICAGO, INDIANA

For more information, turn to Reader Service card, circle No. 563

***Lightweight plastics** sheets are bonded to form largest radar board.*

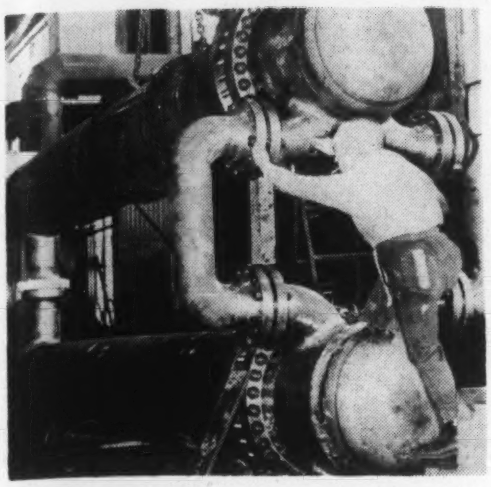
manufactured. The sheets were prepared with butt joints and bonded together with quick setting cement. The bonds are said to have excellent optical characteristics and to be invisible under normal light. Under the strong edge lighting of the radar installation, the bonds show up as faint white streaks.

Edge lighting is provided by thin fluorescent tubes mounted directly to all four edges of the giant sheet. A magnesium channel forms the framework of the installation and also conceals the edge lighting. Total weight of the panel, including the magnesium frame, is 3750 lb.

Exchanger Unit Made Entirely of Stainless

A heat exchanger unit recently completed by M. W. Kellogg Co. is fabricated entirely from type 321 stainless steel. It was designed to withstand pressures above 600 psig and temperatures above 650 F on the shell and tube sides.

Each U-type tube bundle shell (see photo) has a 29-in. i.d. In fabricating the unit, the tubes

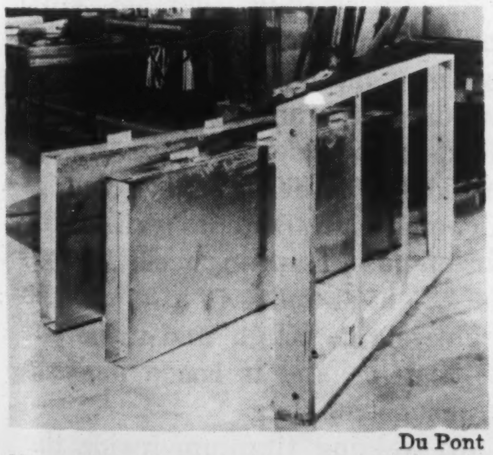


Heat exchanger *is checked for alignment.*

were expanded into grooved tube sheets and then welded by means of inert gas tungsten arc welding. The welds were hydrostatically tested, then tested for leaks using the ammonia sulfur dioxide detection method. All welds were ground smooth and flush, radiographed and die-penetrant tested.

Urethane-Insulated Door Is Strong, Lightweight

By sandwiching urethane foam between sheets of galvanized steel, aluminum or stainless steel, Clark Door Co. has come up with a cold storage door that is not only better insulated but also structurally stronger and half as heavy as conventional doors. Moreover,



Du Pont

Wooden frame *is wrapped with sheet metal prior to pouring foam.*

CRACKING Problems with 316 and 347 Stainless?

CHAMPION'S

16-8-2 Electrodes Offer freedom from CRACKING

HERE'S WHY: New CHAMPION 16-8-2 Stainless Electrodes have a composition which has much higher hot ductility than any other grade of stainless. Produces freedom from cracking in weld, zone of fusion, or parent metal.

HERE'S WHY: Lime type coating deposits extremely clean, sound weld metal. Handles well in all positions. Low spatter. Easy slag removal. Smooth, even and finely rippled weld bead.

HERE'S WHY: Tests reveal that this composition is not subject to embrittlement on aging, and possesses very good stress-to-rupture properties.

Excellent mechanical properties are accomplished with CHAMPION 16-8-2 Welding Electrodes:

Yield	61,000 psi
Tensile	92,000 psi
Elongation in 2"	50 %
Reduction of area	61.8 %

The chemistry is closely controlled to produce less than 4% ferrite in the deposit.

Typical chemical analysis is as follows:

Carbon .08	Chromium 16.19
Manganese 2.24	Nickel 8.00
Silicon .37	Molybdenum 1.79

Other stainless requirements: CHAMPION offers a complete line of stainless electrodes in a full diameter range from 5/64" to 1/4", lime or AC-DC coated.

FOR FULL DETAILS on CHAMPION'S 16-8-2 or other stainless electrodes write to:

The **CHAMPION** Rivet Co.

Cleveland 5, Ohio • East Chicago, Indiana

For more information, turn to Reader Service card, circle No. 562

700 PARK CLOSED-DIE FORGINGS

. . . Wt. 2750 Lbs. Ea.

SAVE
MACHINING TIME
Eliminate
"POROSITY REJECTS"

for manufacturer of automotive glass-making machinery

A Park sales engineer showed this manufacturer of an automated glass-making line how to save money by using large, closed-die forgings. These Park closed-die forgings were closer to being completed parts—needed a minimum of final machining. Uniform in quality, they required less inspection. And there was no danger of investing expensive machine time in parts—then have them rejected because they contained "blow-holes" or porosity defects.

One of the largest production runs of closed-die forgings ever scheduled for the machine tool or machinery field, these 700 forgings, each weighing 2750 lbs., were produced in Park's shops in record time.

Let our sales engineers show you how a Park closed-die forging can cut down machine time and rejects—increase strength and safety on your product requirements.

Die Forging Specialists Since 1907

THE PARK DROP FORGE CO.
775 EAST 79TH ST. • CLEVELAND 3, OHIO

Carbon, Alloy, Heat-Resistant Alloy, and Stainless Steel Closed-Die Forgings from 5 lbs. to 5000 lbs.

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***Liquid urethane** is poured into several door frames at a time.*

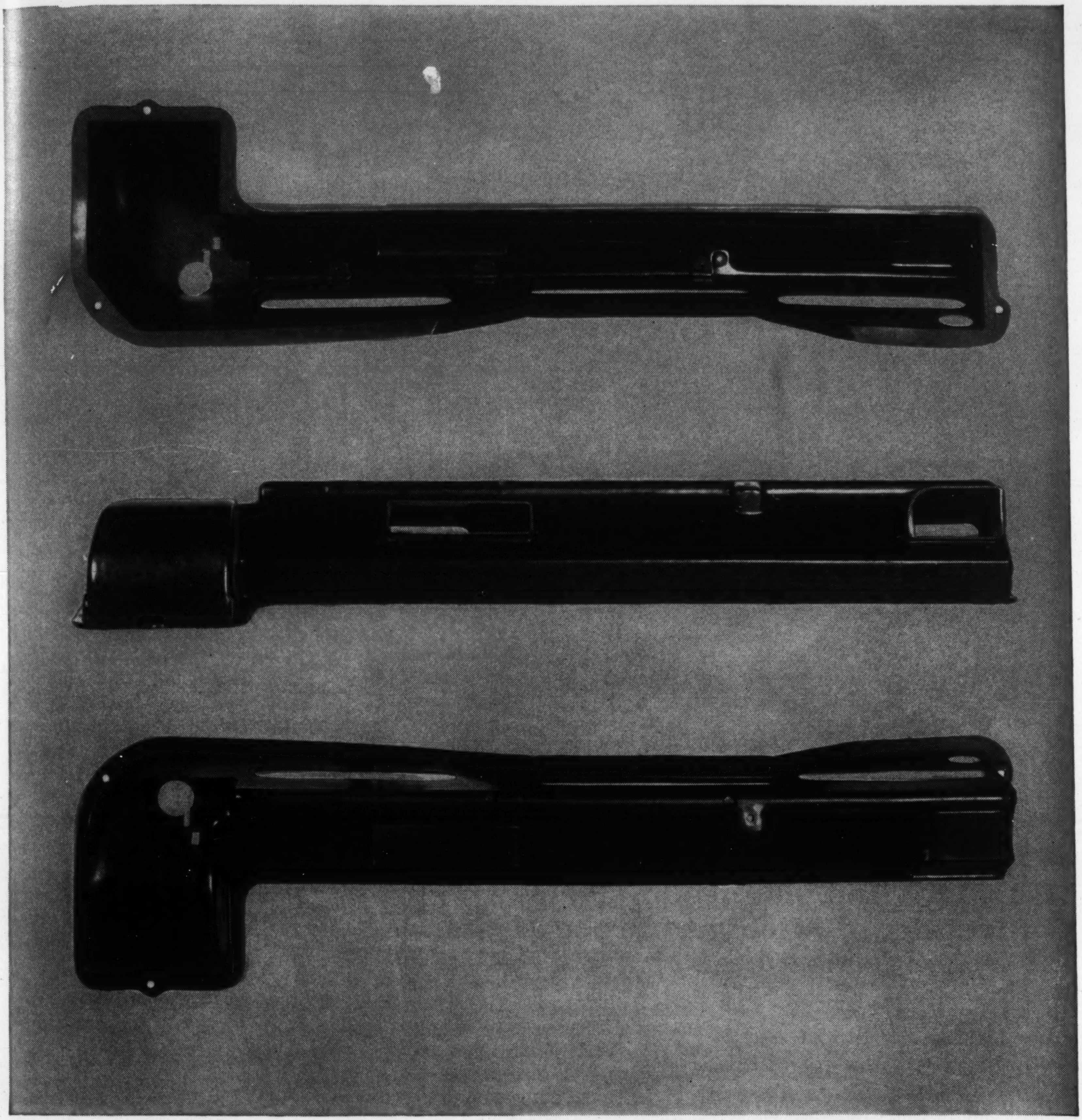
the doors are easily and economically fabricated.

First step in fabricating the doors is to provide a frame for the foam. Since urethane foam adheres equally well to metal or wood, a simple wooden frame is sufficient. Sheets of galvanized steel, aluminum or stainless steel are then wrapped around the frame (see photo above), and liquid foam is poured through slots at the edge of the door frames. The foam expands within 10 min and is allowed to stand overnight (see photo below). The door is sealed and, after hardware is added, is ready for use.

Welding Titanium in Plastics Bubble

A transparent, flexible vinyl bubble is providing an easy-to-set-up, inert-gas enclosure for welding titanium engine parts at Pratt & Whitney Aircraft. Fabricated by Pioneer Valley Plastics Co. and using Bakelite's vinyl, the argon-gas-containing welding tent is 4 ft high and 4 ft in dia. It is lightweight, tough and resistant to tearing, and it has a low gas transmission rate.

In welding titanium inside the plastics bubble, the part is put in place and argon gas piped in. The



Heater housing, a premix molding by Woodall Industries, Inc., Detroit, Michigan.

Premix moldings save time, money and trouble

If your product calls for reinforced plastics, you'll save time, money and trouble with premix moldings. Small or large, simple or complex, you'll get quality molding faster and at less cost when resin and reinforcing fiber are blended beforehand.

Premix moldings eliminate resin-rich areas, provide uniform wall thicknesses and strength. They eliminate many finishing operations necessary in hand lay-up molding. Slots, grooves, holes, bosses and parts with varying wall thicknesses are formed in the mold. For strong, rigid, reinforced plastics, premix moldings have proved ideal . . . on the production line as well as in the finished product.

Polyester resin with Dow Vinyltoluene or Dow Styrene offers all the special properties necessary for successful premix moldings. Specify resins based on vinyltoluene—Dow supplies vinyltoluene to resin manufacturers. THE DOW CHEMICAL COMPANY, Midland, Michigan, Plastics Sales Department 1888J-1.

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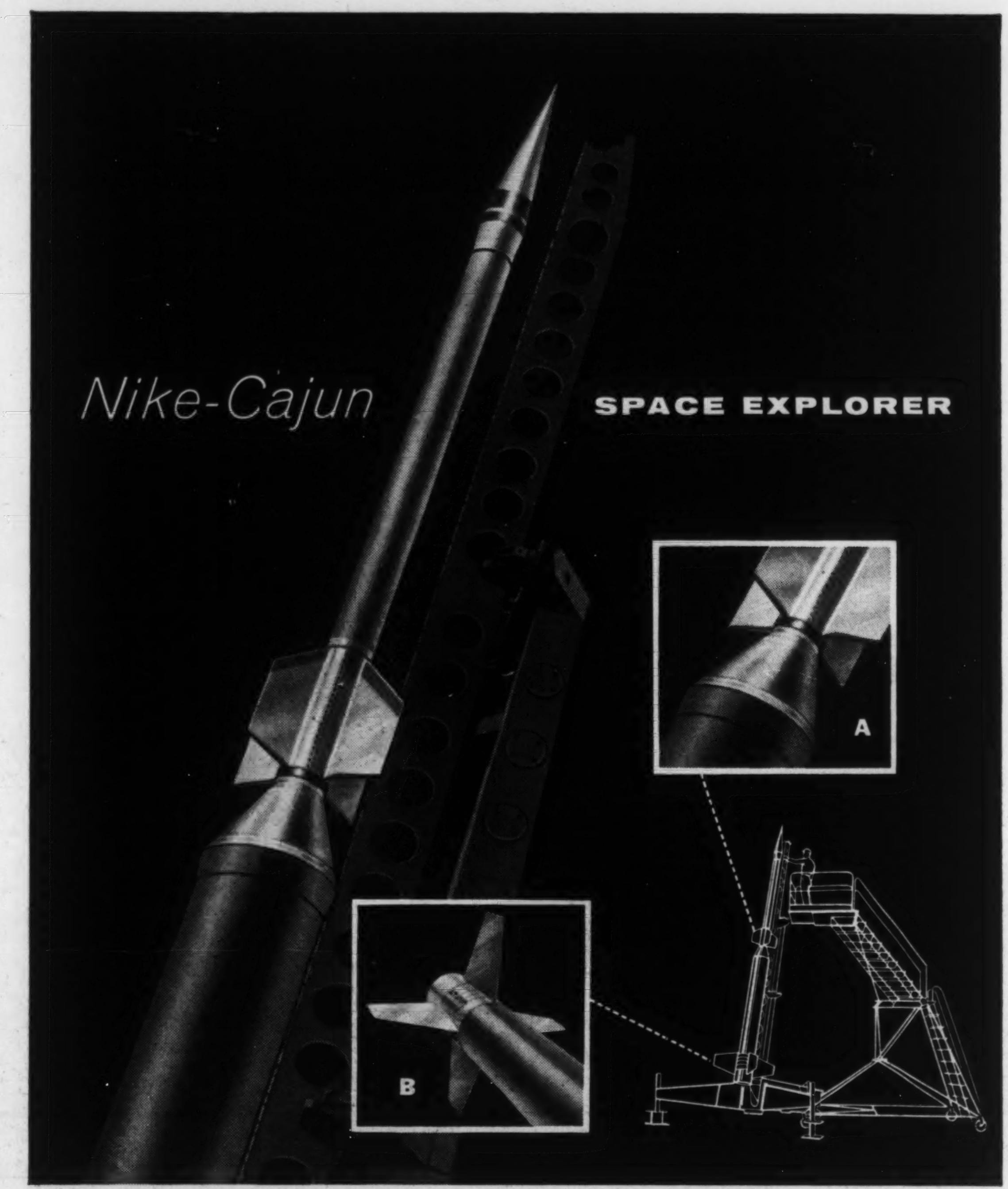

How Magline Magnesium Helps University of Michigan Probe Mysteries of Upper Atmosphere

Time: *International Geophysical Year*
Launching Site: *Fort Churchill, Canada*
Objective: *Upper air research . . . 100 miles above the earth*

Magnesium is playing an important role in the success of the Nike-Cajun sounding rocket. Cost-saving design components, made by Magline have eliminated earth-binding pounds from the rocket . . . while meeting the rigid demands of supersonic speeds!

Magline magnesium improves down-to-earth products too. In automobiles, office machines, industrial equipment, consumer durables—wherever weight and cost are important, design engineers are finding a practical solution with magnesium. World's lightest structural metal, magnesium can be cast, formed, extruded, drawn or worked into virtually any size or shape! Tooling costs are lower . . . machining, fabrication, processing, handling, assembly costs too! Put Magline experience to work for you. Four plants to serve you . . . with complete facilities for cast or fabricated products. Design and technical service available.

MAGNESIUM COMPONENTS OF NIKE-CAJUN ROCKET:

A Coupling is a cone-shaped magnesium sand casting which keeps the two stages of the rocket integral until differential drag separates them.

B Each Nike fin assembly consists of a four-piece quadrant and fin. Quadrants are magnesium sand castings. Fin is a weldment of magnesium structural plate and magnesium sand castings.

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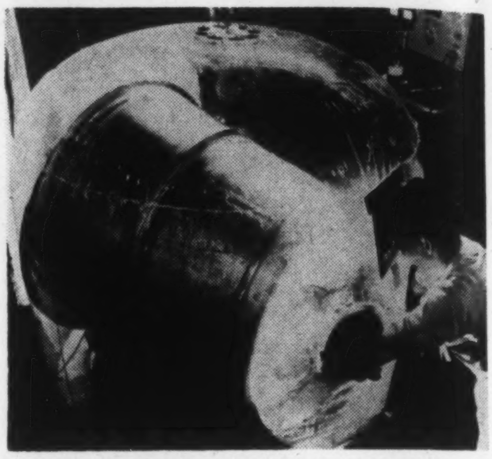


***Vinyl bubble** makes titanium welding easier.*

argon forces atmospheric air out through several small valves at the top of the tent and its pressure keeps the tent inflated. Sleeves with attached gloves are built right into the tent to provide the welder with ready access to the part and, at the same time, prevent the gas from escaping. In addition, a shield is provided to filter out the harmful glare of the electrode.

A modification of this welding technique is used for certain steels where helium gas is used instead of argon.

Plastic-Coated Tubing Resists Acid Fumes

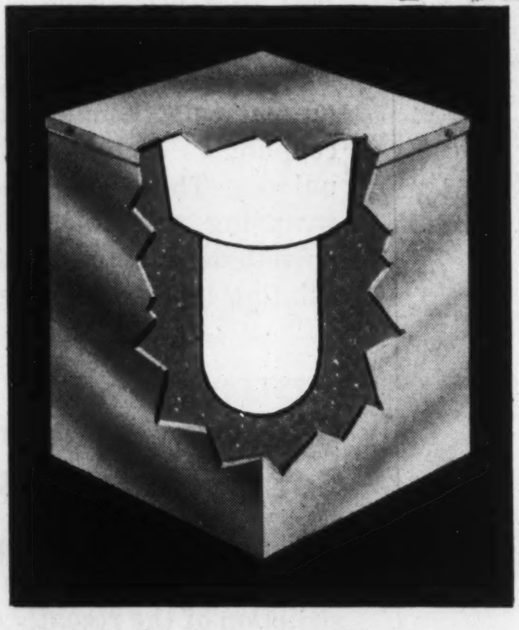
After six years of service in a paper mill, polyethylene-coated, light wall, welded steel conduit has outlasted standard heavy wall electrical conduit ten to one in highly corrosive atmospheres.

Previously, sulfurous acid fumes thrown off from the mill's wood chip digester retorts combined with moisture to corrode standard heavy wall steel conduit so badly in certain mill areas that it had to be replaced as often as every six months. Six years ago, the conduit was replaced with the standard galvanized, light wall, welded steel tube coated with

For more information, circle No. 488 ➤

Precious International Cargo goes to market in

URETHANE FOAM!



This 18" x 18" x 24" export container weighs only 35 pounds. Packed with dry ice, it weighs 45 pounds, holds 100 ampules of semen and is guaranteed to maintain temperature below –100°F for six days in air temperature up to 85°F. Others protect for three weeks!

Many a pedigreed calf grazing on the Argentine pampas or the African veldt was sired by air express! The live sperm of champion American breeding stock has become an important item of world trade.

But packaging presents a problem. The perishable cargo must be shipped in dry ice at temperatures below –100°F.

With ingenious use of rigid urethane foam, Standard Plastics, Inc., Breinigsville, Pa. cut shipping and handling costs for U.S. shippers. Foamed in place to fill a lightweight aluminum shell, urethane makes fabrication simple and fast. It provides thermal insulation that safeguards the contents up to three weeks . . . plus all the needed structural rigidity and impact absorption.

Comparable protection is afforded by urethane-foamed containers for live grafts of human tissue and arteries, biopsy specimens, biologicals, etc.

Unique properties, versatility, low cost and easy fabrication make rigid urethane foams adaptable to many other novel, profitable uses. Perhaps they can benefit your business, too.

A letter outlining your potential application will help us to give you pertinent information about urethanes.

National Aniline does not make urethanes but is a major producer of diisocyanates-nacconates®—basic component of all urethane formulations.

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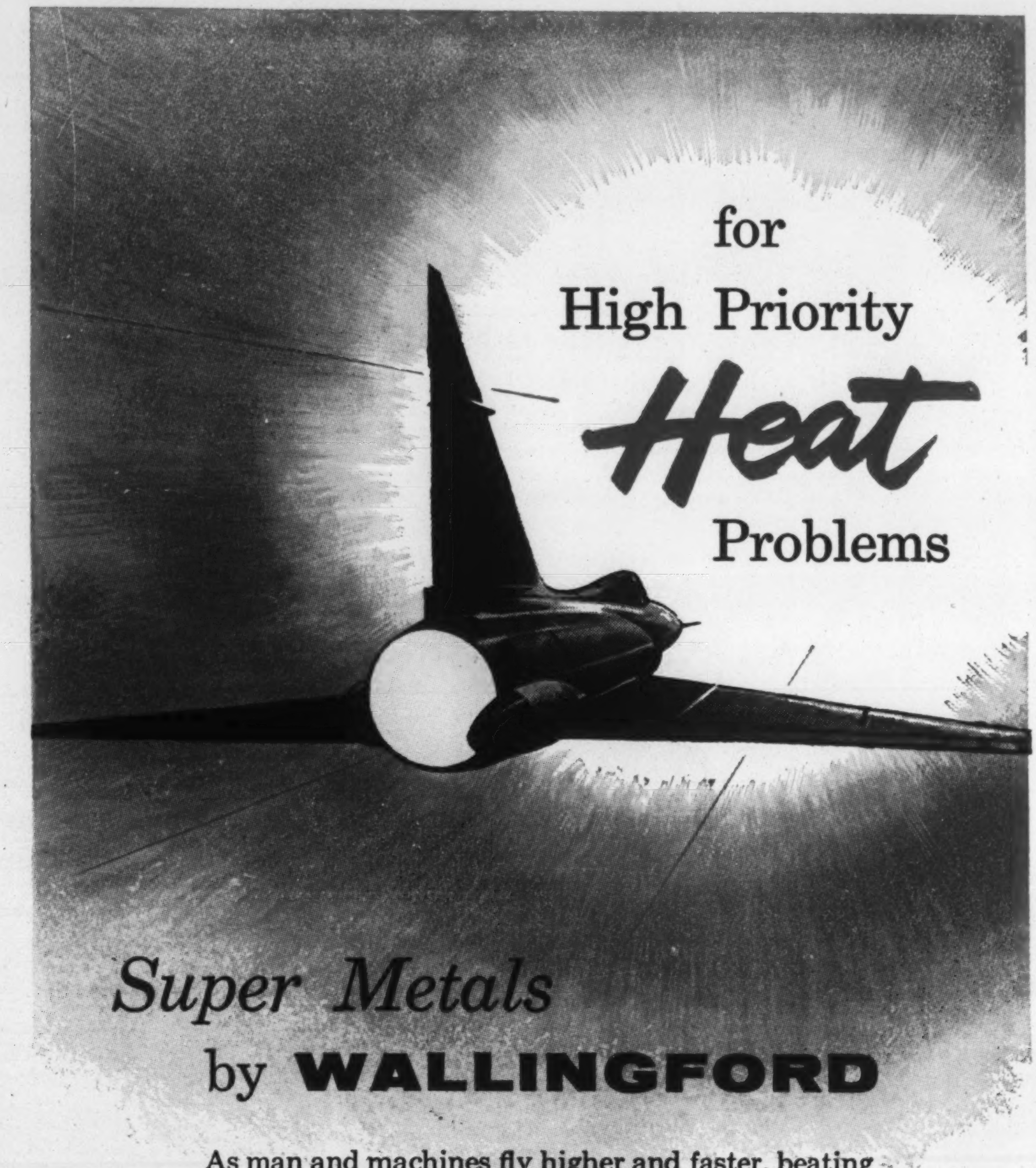

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Problems

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As man and machines fly higher and faster, beating the heat problem becomes more difficult . . . the need for super metals more acute. This is why WALLINGFORD has long engaged in research with super alloys that will successfully pass the rigorous test of high temperature applications.

Among the many super alloys researched by WALLINGFORD are Alloy A-286 and V-36 used for applications in jet engines, gas turbines and turbosuperchargers — turbine wheels and blades, frames, housings and afterburner and tail cone parts.

An unceasing program of metallurgical research and highly skilled personnel qualify WALLINGFORD to help you, whether your need is super metals, or quality stainless steel strip, tube or pipe.

Let us know your high temperature problems . . . we'll help you solve them.

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for over 35 Years

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COLD ROLLED STRIP: *Super Metals, Stainless, Alloy*
WELDED TUBES AND PIPE: *Super Metals, Stainless*

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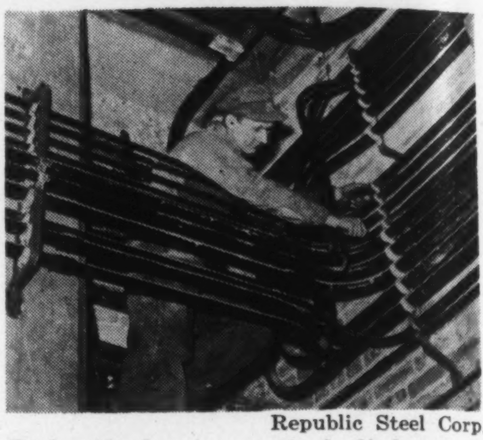

Republic Steel Corp.

***Polyethylene - coated** light wall steel tubing is more resistant to corrosion than uncoated heavy tubing.*

polyethylene, and today it is in much the same condition as when installed.

According to officials who specified the light wall coated conduit in a plant-wide replacement program, installation was easy. The plastic coated conduit requires only simple compression couplings, each serving as a union. These are sealed by wrapping a double thickness of polyethylene or vinyl-backed insulating tape around the coupling.

500 Tons of Aluminum Set Record for Bridge

A record one million pounds of aluminum were used in the construction of the recently completed 3500-ft Walt Whitman Bridge at Philadelphia. With a central section spanning 2000 ft, the bridge uses aluminum's light weight and strength to good advantage. Included among the many operative and structural applications are:

1. Ten all-aluminum overhead traffic light bridges spanning the seven-lane roadway. Each of the traffic control spans weighs 10,000 lb and has a built-in catwalk which allows service and maintenance work to proceed without obstructing traffic in any way.

2. Six all-aluminum overhead

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For more information, turn to Reader Service card, circle No. 507

The least expensive hose is the one you don't keep replacing

Here are three lengths of hose. Take the one on the far right. Subjected to hot oils at high temperatures – it soon deteriorates and fails. Result: time out for maintenance – and a requisition for a new hose.

Now consider the hose in the center. Installed on a severe flexing application . . . it readily fatigues and fails. Result: time out for maintenance – and a requisition for a new hose.

How often does this happen? Often enough to prove that "the *least* expensive hose is the one you don't keep replacing."

While Fluoroflex-T hose (on the far left) costs more initially, its performance actually results in real savings. Costly down-time, excessive maintenance (often at premium rates), product spoilage, interrupted production schedules, disappointed customers – all these are eliminated by Fluoroflex-T assemblies.

With its chemically inert patented tube and its blow-off proof fittings, Fluoroflex-T assemblies are ideally suited for conveying the most corrosive fluids – safely and economically. Write for data.

Most flexible hose problems are quickly solved for good with Fluoroflex-T hose assemblies – as proved by over three years of continuous service on the toughest applications in aircraft, missiles, rockets, and nuclear energy. Consider these qualifications: non-aging, completely inert chemically and flexible over range of —100°F to +500°F, exceptional flex life, lightweight, small O.D., 1000 psi pressures.

® Fluoroflex is a Resistoflex trademark, reg. U.S. Pat. off. ® Teflon is a DuPont trademark.

Originators of high temperature fluorocarbon hose assemblies

Resistoflex
CORPORATION
Roseland, New Jersey • Western Plant: Burbank, Calif. • Southwestern Plant: Dallas, Tex.

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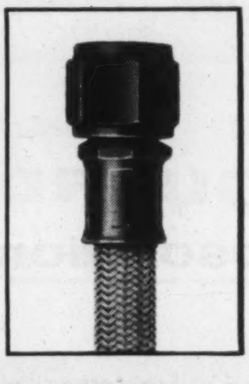


Aluminum Co. of America

***Aluminum** sidewalk grating.*

sign trusses weighing a total of 75,000 lb. Three of these structures are placed on each approach to hold aluminum direction and route signs.

3. A roadway lighting system composed of 475 specially designed aluminum lighting standards.

4. An aluminum grating sidewalk. Although the bridge has no regular pedestrian walkway, the sidewalk has been provided for motorists having car trouble. The walkway, more than a mile in length, is composed of aluminum grating sections 2-1/3 ft wide which run the entire length of the bridge (see photo).

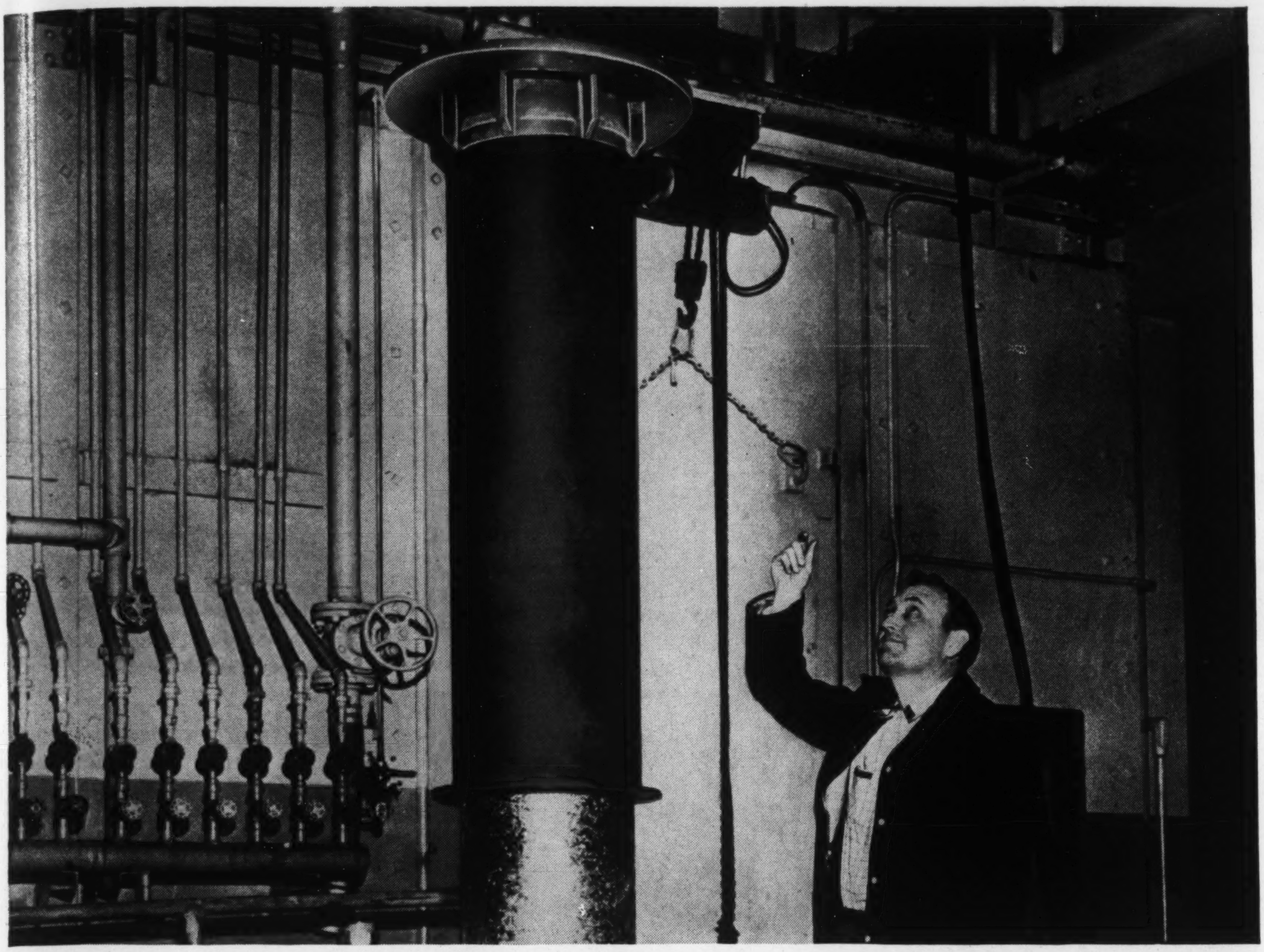
5. More than four miles of aluminum railing.

In addition, to guard against corrosion of steel members, the entire bridge is protected with aluminum paint.

Carbon Dioxide Welding for Mass Production

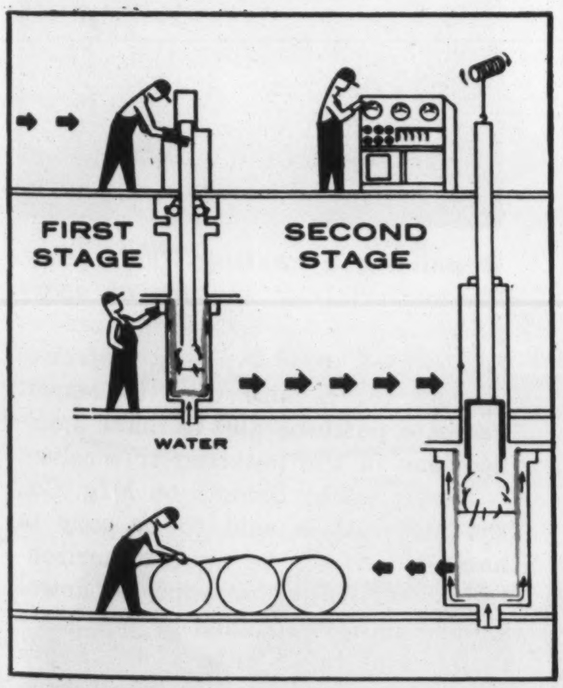
For the first time, carbon dioxide welding is being used on a full-scale, highly automatic production line, according to Westinghouse Electric Corp.

Used by Ford Motor Co. to weld rear axle housings into integral units (see photo), the process is said to increase welding speeds and to reduce materials and maintenance costs. In Ford's opera-



STRIPPING titanium ingot from crucible fabricated from Anaconda large-diameter seamless copper tube. During melting, the crucible is water cooled.

How Copper helps make superior Titanium Ingots



SPONGE TITANIUM pressed into electrodes is melted in the first-stage arc furnace, forming ingots. Several such ingots are welded together and used as an electrode in the second melting. Double melting gives homogeneous, uniform ingots. A vacuum in the crucible assures low hydrogen content.

Titanium and titanium-alloy ingots that are homogeneous and have low carbon and hydrogen content are difficult to produce. Mallory-Sharon Titanium Corp. of Niles, Ohio, however, originated the double-melting process, "Method S," for production, which does the job.

A major factor in the successful production of ingots of sound structure is the use of water-cooled copper crucibles. Mallory-Sharon found that copper met the requirements for a satisfactory crucible material, particularly because of its high thermal conductivity.

Mallory-Sharon fabricates some of its crucibles more easily and quickly, using large-diameter Anaconda seamless copper tube for the body of the crucible. Various sizes are used for the crucibles—for example 20″ I.D. x ½″ wall thickness; and 15¼″ I.D. x ⅜″ wall thickness. These big Anaconda tubes are now playing a key role in producing the ever-growing tonnage of the new structural metal so vital in the production of America's jet planes.

The American Brass Company produces the widest range of seamless tubes available to industry. At one end are tubes in copper and copper alloys up to 26″ I.D. At the other are the capillary tubes as small as .032″ O.D. and wall thickness of .005″—for instrument control, activating lines, and other precision purposes.

Whatever your tubing problem, see your American Brass Company representative. Or write: The American Brass Company, Waterbury 20, Conn.

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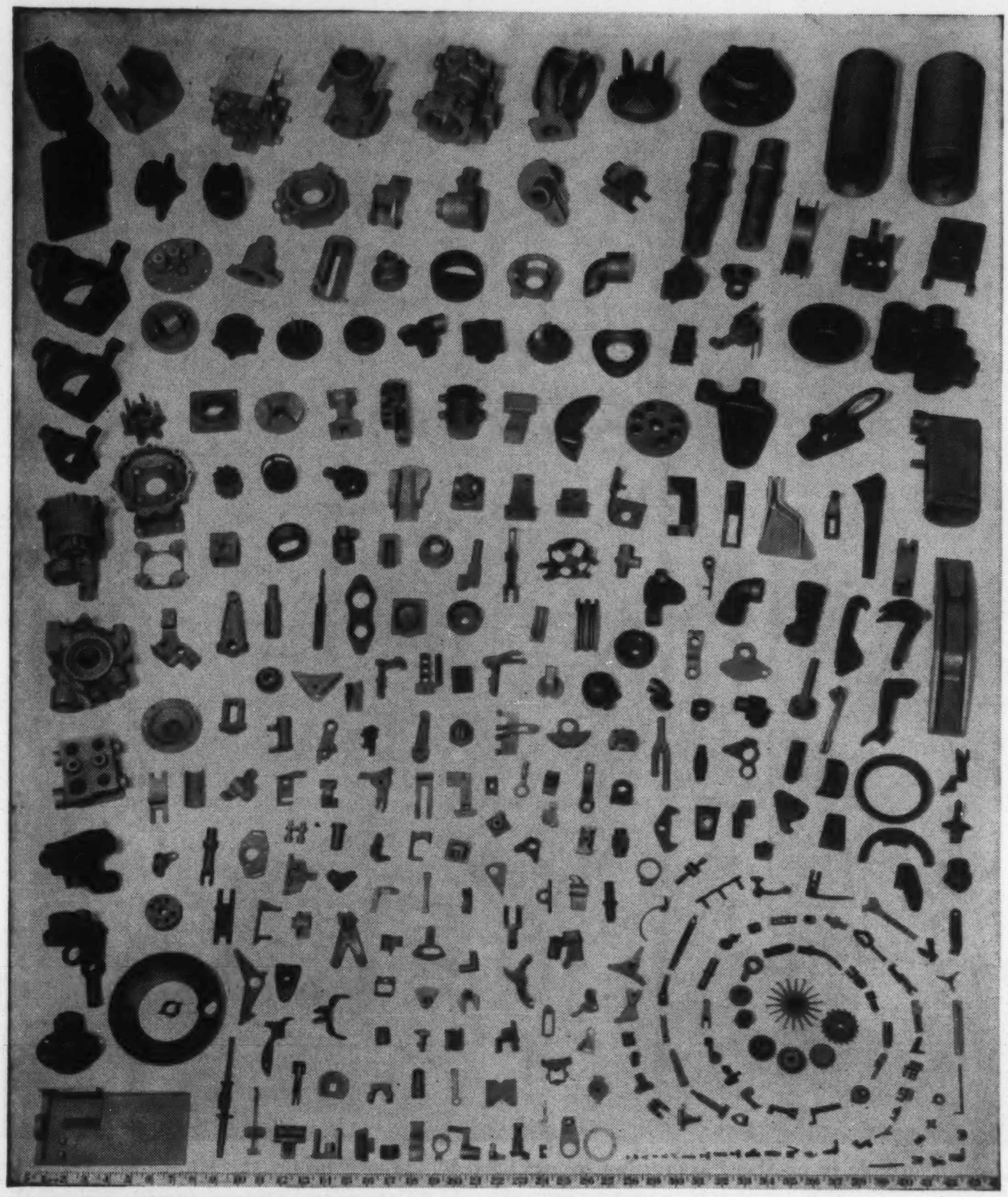

Investment castings

¼ ounce to 30 pounds . . . up to 12 inches in length . . . 160 ferrous and nonferrous alloys

Precision Metalsmiths makes them all—a million pieces for your production or a few at a time, as you develop a product. Pictured above are some of the investment castings we're making regularly.

Cast to close tolerances and accurate in details, such parts require surprisingly little finishing. Expensive pre-assembly machining is avoided, since complicated parts are produced as single units. We do the assembling with expendable patterns.

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pour yourself an assembly with

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Investment Castings

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Carbon dioxide *welding increases welding speeds, reduces costs.*

tions, parts are welded at speeds up to 140 in. per min. Outstanding feature of the technique is that the powdered flux of the submerged arc process is superseded by a jet of carbon dioxide that forces normal atmosphere away from the weld area.

Repairing a casting—This putty-like material—a mixture of epoxy resin and powdered aluminum—is being used to salvage a defective casting. It is also used to cement gates to patterns and to make modifications in the patterns themselves.

Developed by Smooth-on Mfg. Co., the material is said to be easy to handle and can be applied horizontally, vertically or upside down. Curing is accomplished by polymerization and takes only a few hours at room temperature. The cured patch is claimed to have a compressive strength of 14,400 psi and a Rockwell hardness of M70.

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CINCINNATI Hydroform MACHINES

ALUMINUM

2 Draws

2 Draws

2 Draws

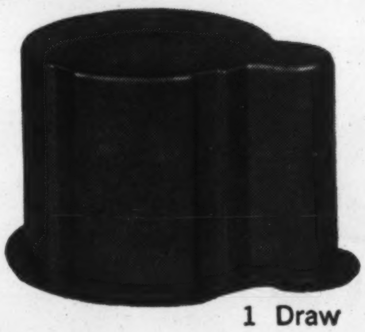
2 Draws

1⅓ Draws

give you fast delivery

STEEL

1 Draw


1 Draw

2 Draws

2 Draws

1 Draw

of parts of almost any shape

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1 Draw

1 Draw

1 Draw

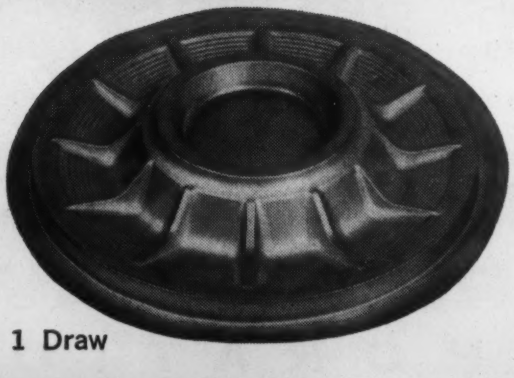
2 Draws

at savings up to 90% in tool costs

STAINLESS

2 Draws

2 Draws


1 Draw

1 Draw

3 Draws

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Blueprint or sketch, with details of operation, will bring you complete information on the AlSiMag Alumina best suited for your application. NEW Bulletin 575 covering several of the most popular AlSiMag Aluminas sent on request.

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PRICES AND SUPPLY

The Outlook

by Herman B. Director, *Consultant, Washington, D. C.*

Still plenty of copper

Curtailment of copper production now amounts to about 11,500 tons a month. Of this amount, 8700 tons represent curtailment by U. S. producers and 2700 tons by foreign producers (not including the Chileans who have indicated a willingness only to allow small independent fringe producers to close down). Supply, nevertheless, exceeds demand by a wide margin. As a matter of fact, production in 1957 will exceed production in both 1955 and 1956, and consumption will be considerably lower than it was in 1955 and 1956.

The London price of copper is now about equivalent to 24¢ per lb. The U. S. price stands at 27¢ for primary copper and 26¢ per lb for custom smelters. The chances are that there will not be an increase in consumption sufficient to sustain these prices and we expect the price to drop to 25¢ per lb.

In the meantime, producers are exerting pressure on the Government to increase the 2¢ excise tax on copper imports. This 2¢ tax goes on automatically when the price reaches the 24¢ "peril point" for one month's time. Some producers want the excise tax raised to 4¢ and the "peril point" level raised to 30¢ per lb. We feel that this is just an "asking price" on the part of producers. No one really believes that the Government will exclude foreign copper at anywhere near 30 to 34¢ per lb. Actually, the tariff will not increase consumption and so it can, therefore, be no long term solution to the problem of finding more uses for a material abundantly available.

Stainless steel consumption down

Although production of stainless steel has kept up well as compared with other steels, a goodly share of it has wound up in warehouse stocks. Most consuming areas, especially the automotive and appliance, have held back on large scale purchases. As a result, consumers should be able to get all the stainless they want, whether it be nickel or non-nickel-bearing.

Nickel no longer scarce

An indication of the fact that nickel is no longer scarce in this country is the recent relaxation of the virtual embargo on the export of nickel-bearing materials. Up until recently, only contaminated nickel scrap unusable in the U. S. could be exported, and then only if the exporter certified that no less than 90% of the contained nickel would be returned to the U. S. in usable form.

Supplies of primary nickel in the U. S. are the highest in history. Stocks in consumers' hands are reported to exceed 45 days' supply, whereas actual consumption has not increased over the first part of 1957 when it was alleged that the shortage of nickel was hampering production.

Mylar prices down

Increased production and use of Mylar are reflected in the fourth cut in Mylar prices in three years. The latest cut is 25¢, bringing the price down to $2 per lb. The reduction, incidentally, comes at a strategic time: auto makers, who already use large quantities, are now getting into volume production of new cars.

Plenty of titanium

The Government has reduced the amount of titanium mill products reserved for military purposes. Up until recently, 95% of all titanium was reserved; only 75% is now reserved. This change, however, means very little, since neither military nor civilian consumers have taken up their allotments. One thing is certain and that is that there is plenty of titanium available for anyone who desires to use it.

Steel consumption up

Consumption of steel (excluding stainless) is higher than industry sources had expected and it is still climbing. Supply, however, is sufficient, except for pipe, heavy plates and structural shapes.

Capacity increases this year will boost the indus-

◄ For more information, circle No. 452

The Outlook—continued

try from 133.4 million ingot tons to 141 million tons. A sizable segment of this increase will come from upgrading existing facilities rather than actual building of new plants.

Cadmium prices may decrease

Since cadmium is a by-product of zinc refining, its price should not fluctuate rapidly. However, there is more of it available than is being used, and the United Kingdom recently reduced cadmium prices for the first time since January 1956. In the face of fairly consistent but not increasing consumption, U. S. producers will probably follow suit.

Mercury prices decrease

Reduced consumption of all but very small lots of mercury is tending to produce lower prices. Latest quotations are $244-277 per flask, with sales mostly at the $244 level. A reduction to the U. S. support level of $225 per flask is in the cards.

Aluminum can venture to be costly

The agreement between Reynolds and Esso to produce and use aluminum for petroleum containers is, on the face of published accounts, bound to be a costly venture. The price that Esso will pay for the aluminum container is said to be the same as for the steel container.

On the basis of materials costs alone (and even taking into account the fact that aluminum is lighter and will make more cans per pound), the aluminum can is at best what the retail trade calls a "loss leader." Recovery of scrap by providing gas stations with a pressing machine will also be costly and unless some provision is made to reimburse the local gas station operator for his effort, chances are the aluminum can will wind up in the same trash bucket the steel can now goes into.

Abundant supply of vinyls

As is the case with polyethylene, supply of vinyl chloride exceeds demand. Although industry capacity is over 850 million pounds, consumption will probably not exceed 600 million pounds. As a result, prices may be reduced.

Director on Lead-Zinc Tariffs

A Tariff Commission recommendation to increase duties on lead and zinc was turned down by the Administration in 1954 on the grounds that the State Dept. would undertake informal negotiations with producing countries to reduce shipments to the U. S. on a voluntary basis. Another argument advanced against tariffs was that foreign suppliers would retaliate by restricting shipments of other more "strategic" materials into the U. S.

Both arguments have been since proved wrong. Not only did foreign suppliers not curtail their shipments of lead and zinc into the U. S., but they are now pressuring the U. S. to buy more and more of their "strategic" materials, including chromium, manganese, tungsten, titanium, fluorospar, copper and others.

Now the Administration has indicated a willingness to go along with a Tariff Commission recommendation before Christmas.

The upshot of the whole thing, as we see it, is that there will undoubtedly be a recommendation to increase the tariff on lead and zinc to the maximum allowable. The present duty on lead is 1 1/16¢ per lb; the maximum allowable is 2.55¢ per lb. The slab zinc duty is 0.7¢ per lb and the maximum allowable is 2.1¢ per lb.

We expect that the President will accept the Commission's recommendation and that the tariff will be imposed. The effect on foreign production, however, will not be great since it is likely that foreign producers will absorb the tariff and continue to ship large quantities of lead and zinc into the U. S.

So far as the consumer is concerned, the tariff will tend to maintain the current price. In fact, the threat of a tariff and U. S. stockpile purchases are, in our opinion, the only things which have kept the price from falling.

On the other hand, if the Government stops buying lead and zinc when the duty is imposed, we will be right back where we started. The surplus of metal on the market will increase and the increase in duty will not discourage either domestic or foreign production. The next step will be industry pressure for imposition of import quotas along with the tariffs.

Here is an interim report on . . .

1957 Metal Production, Consumption and Prices

■ Although complete data on consumption, production and prices of key metals for the year 1957 are obviously not available, several interesting facts are already discernible. For example, it is evident that the only key metal still not abundantly available is nickel. It is also obvious that the copper shortage of not so long ago is decisively over. Here are preliminary statistics on some key metals.

Copper—During the past year and a half the price of copper has been reduced more sharply than has any other nonferrous metal price. It has dropped from over 45¢ per lb in 1956 to under 30¢ per lb in 1957, and most observers have no better idea now as to when and where stabilization will occur than they did last year. The price is currently on a par with aluminum and there is every reason to believe that it will decrease further in the near future.

As a result of these drastic price reductions, however, many producers have cut their output and it seems that total mine production in 1957 will probably be around 5% lower than it was in 1956. Consumption will be about 10% lower.

Lead—Both production and consumption of lead this year will be about 5% lower than they were in 1956. However, there is more lead available than is being used, and the price has decreased an average of 10% for the year. The abundance of lead on the market is attributed, by many producers, to the great amount being imported from foreign sources. As a result, pressures have been brought to bear on the Government to increase lead and zinc tariffs. Chances are that recommendations for tariff increases will soon be proposed and approved.

Aluminum—Aluminum production this year is expected to be about 5% lower than it was last year. However, over-all consumption is expected to decrease by about 15% or more. The 1¢-per-lb price increase initiated in August raised the annual average price by about 5%. Indications are that, as a result of the decrease in consumption, aluminum prices will not change much for at least a year.

U. S. PRODUCTION OF KEY METALS (1000 Short Tons)

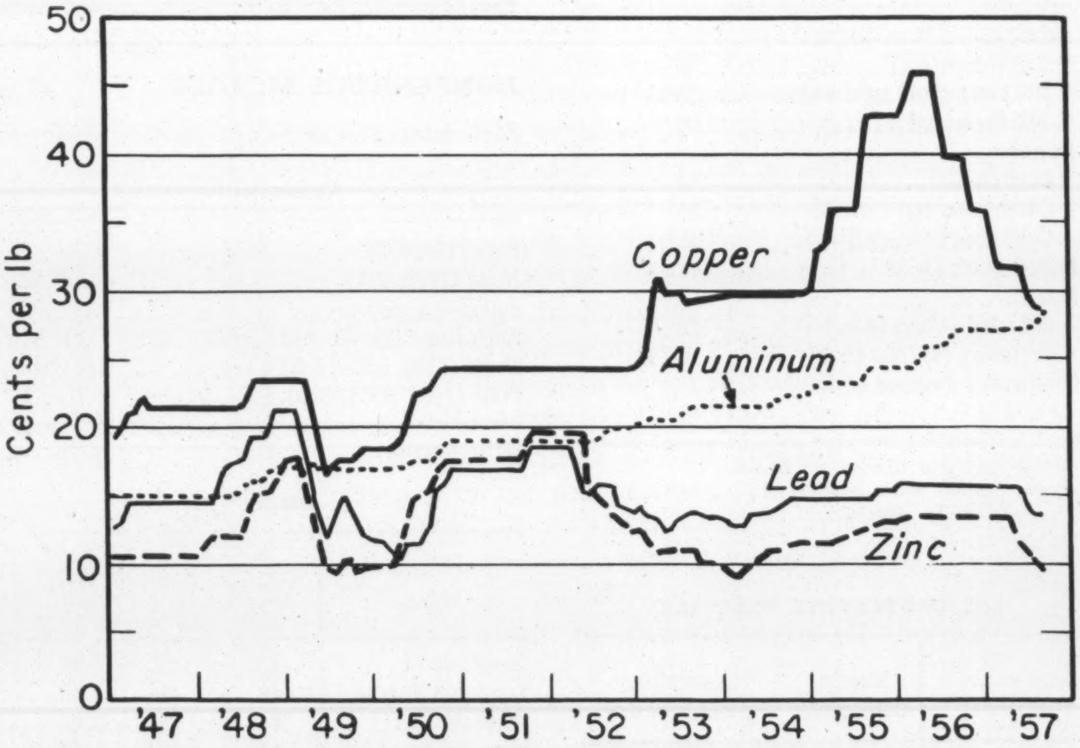
Metal ➜	Aluminum	Copper	Lead	Zinc	Steel
1954	1461	835	325	473	88,000
1955	1566	999	338	515	117,000
1956	1679	1100	348	538	115,000
1957[a]	1600	1034	334	511	117,000

[a]Estimated.
Source: Bureau of Mines.

U. S. CONSUMPTION OF KEY METALS (1000 Short Tons)

Metal ➜	Aluminum	Copper	Lead	Zinc	Steel[a]
1954	1650	1255	1095	884	63,000
1955	1800	1502	1213	1120	85,000
1956	1900	1514	1190	1005	83,000
1957[b]	1500	1350	1100	910	—

[a]Shipments. [b]Estimated.
Source: Bureau of Mines.



Nonferrous metal prices from 1947 to 1957.

Zinc—The annual average price of zinc has decreased in 1957 by about 15%. Although consumption of zinc in some areas has increased, over-all consumption has decreased by about 10%. Production is down 5%. Increased tariffs and import quotas are expected to be imposed in the near future.

(continued on p 250)

Prices of Materials

Changes since last month are bold-faced

NONMETALLICS

Prices for large quantities for range of grades, color, sizes; given in $/lb

RUBBER

Material	Dry	Latex
Butadiene-Acrylonitrile	.49-.65	**.46-.54**
Butadiene-Styrene	.17-.30	.22-.32
Butyl	.23-.28	—
Neoprene[a]	.39-.75	.37-.47
Silicone[a]	1.90-4	—
Polysulfide[a]	47-1	.70-.92
Natural	.33[b]	—

[a]Less than carload quantities.
[b]Average spot price for month of Sept.

GLASS FOR REINFORCED PLASTICS

Fabric ($/yd 38 in. wide)[a]	
112 Woven	.48
181 Long-shaft satin weave	.03
143 Unidirectional	1.00
Roving[a]	
Continuous	.40
Continuous spun strand	.36
Continuous chopped spun	.38
Milled fibers (1/32-¼ in.)[a]	.45
Mat	
Chopped strand (2 in.)[a,b]	.52-.72
Surfacing ($/1000 sq ft)[c]	10-19
Continuous chopped strand (¼-2 in.)	.40

[a]Price includes binder or finish.
[b]Price varies with binder.
[c]0.010-0.020 in. thick.

THERMOSETTING PLASTICS

Material	Molding Compounds	Laminating, Casting Resins
Alkyd	.34-.53	—
Epoxy	—	.45-.80
Melamine	.42-.45	.40-.41
Phenolic	**.21-.40**	.17-.34
Polyester	.42	.32-.50
Silicone	2.75-5.40	1.55-1.74[a]
Urea	.19-.33	—

[a]60% solids content.

All prices are approximate and given solely for general guidance of those responsible for materials selection.

THERMOPLASTICS

Material	Molding Compounds	Sheet (.030-.250 in.)	Rod		Tube	
			⅛-¼ in.	⅜-1¼ in.	⅛-¼ in.	⅜-1¼ in.
Acrylic	.51-.59	.49-2.15	.90-1.15	.80-.90	1-1.15	.90-1
Cellulosic						
Acetate	.36-.65	.92-1.16	.75-1	.65-.75	.85-1	.75-.85
Butyrate	.50-.72	1-1.28	.95-1.20	.85-.95	1.05-1.20	.85-1.05
Nitrate	—	1.60-2.73	1.45-1.75		2.25-5.00	
Propionate	.51-.63	—	—		—	
Fluorocarbon						
CFE	7-8	15-23	18-22	14-20	20-22.50	16-20
TFE	4.50-7.45	14.30-11	13	13	13	13
Nylon	1.18-2.30	—	3	3	3	3
Polyethylene	.35-.56	.85-1	.75-1	.65-.75	.85-1	.75-.85
Polystyrene	.26-.44	.57-.61	.65-.90	.55-.65	.75-.90	.65-.75
Vinyl	.27-.43	.62-.92	.75-1	.65-.75	.85-1	.75-.85

NONFERROUS METALS

Mill base prices for large quantities; given in $/lb except where indicated

ALUMINUM

Pig (99-99.9%)	.26-.28
Ingot (99-99.9%)	.28-.30
Foil (5-0.5 mil)	.55-.77
Alloy Ingot (13, 43, A132, 214)	.29-.32
Sheet (1100, 3003; 3-0.03 in.)[a]	**.43-.47**
Plate (1100, 3003, 5050, 3004, 5052)[a]	.40-.43

[a]Mill finish.

BRASS

Form	Cart., 70%	Low, 80%	Red, 85%
Sheet, Strip	**.43**	**.46**	**.46**
Seamless Tubing	**.46**	**.48**	**.49**
Rod (not f.c.)	**.44**	**.45**	**.46**
Wire	**.44**	**.46**	**.47**

COPPER

Ingot (elec)	**.27**
Sheet, Strip (hot rolled)	**.49**
Seamless Tubing	**.49**
Rod, Drawn	**.47**
Rod, Free Cutting	**.57**
Wire	
Round	**.32**
Square, Rectangular	**.35**
Magnet	**.40**

LEAD

Common Grade	.14

MAGNESIUM

Pig (98.8%)	.36
Ingot (98.8%)	.37
AZ91B Ingot (die casting)	.37
AZ91C Ingot (sand casting)	.41[a]

[a]Delivered price.

NICKEL

Form	"F"	"A"	Monel
Ingot	75[a]	—	—
Rod	—	1.07	.89
Sheet, C.R.	—	1.26	1.06
Strip, C.R.	—	1.24	1.08
Seamless Tube	—	1.57	1.29

[a]Delivered price.

TIN

Primary[a]	.93-.94

[a]Delivered price.

(continued on p 244)

HAYNES investment casting solves the *tough* design problems

TURBINE WHEELS mass-produced for operation up to 1700 Deg. F

Special inspection equipment guarantees accuracy. Examinations by Gamma Ray (above) is one of a number of inspection methods used at Haynes Stellite Company's plant to insure top quality control.

Turbine wheels with intricate blading—some as thin as 0.020 in.—and ranging in diameter from 2 to 21 in. are now mass-produced economically by HAYNES' investment-casting method. The blades and wheel are produced as one integral part to close as-cast tolerances.

HAYNES' investment-casting method offers the design engineer a selection of alloys developed for economical operation over a wide temperature range—from room temperature to 1700 deg. F. The cast wheels have high strength and are capable of operating at speeds in excess of 42,000 revolutions per minute.

The freedom to select alloys for performance and to design for top efficiency is one of the big advantages of HAYNES' investment-casting process. For full details, write for the booklet "HAYNES' Investment-Casting." Address Haynes Stellite Company, Division of Union Carbide Corporation, General Offices and Works, Kokomo, Indiana.

HAYNES
ALLOYS
HAYNES STELLITE COMPANY
Division of Union Carbide Corporation

UNION CARBIDE

"Haynes" and "Union Carbide" are registered trade-marks of Union Carbide Corporation

For more information, turn to Reader Service card, circle No. 524

new . . . booming . . . stainless steels call for consistent analysis

MANGANESE	99.9 % MINIMUM
CARBON	0.004 % MAXIMUM
SULPHUR	0.024 % MAXIMUM
IRON	0.001 % MAXIMUM
HEAVY METALS	0.005 % MAXIMUM
PHOSPHORUS	NOT DETECTABLE IN 25 GRAM SAMPLE
SILICON	SPECTROGRAPHIC TRACES ONLY
HYDROGEN	0.015 % MAXIMUM

and ELECTROMANGANESE® has it

Stainless steel is on the move. Industry after industry is attracted by its recent strides in transportation equipment, appliances, architectural trim, household and store furnishings. And of all the stainless steels, the most stimulating seem to be the new 200 Series, characterized by high manganese, low nickel, content.

But—high manganese content also means consistent analysis in this critical alloying agent. The percentage of each impurity must be known and consistent in melt after melt. This calls for the purest commercial manganese available . . . Foote electrolytic manganese. Electromanganese, by trade name, consistently provides 99.9% manganese content in the analysis shown above. If you have a hydrogen problem, even this can be reduced to 7.5 ppm maximum in a *Hydrogen-Removed* grade. Nitrided manganese is available in Foote's high-purity Nitrelmang.® But just as important as consistent analysis is economy. And here Foote's alloying agents enable you to get the necessary manganese content in the most efficient way.

The 17 years' experience in manganese alloying available from Foote's Electromanganese Division is an important first step when you decide to really pursue the growing stainless steel market. A letter will bring a Foote engineer to your desk. Or, you can get further information by writing to our Technical Literature Department, Foote Mineral Company, 408 Eighteen West Chelten Building, Philadelphia 44, Pa.

Foote
MINERAL COMPANY

SALES OFFICE: *Electromanganese Division, Knoxville, Tennessee*
RESEARCH LABORATORIES: *Berwyn, Pennsylvania*
PLANTS: *Cold River, N. H.; Exton, Pa.; Kings Mountain, N. C.; Knoxville, Tenn.; Sunbright, Va.*

ELECTROLYTIC MANGANESE METAL • WELDING GRADE FERRO ALLOYS • STEEL ADDITIVES • COMMERCIAL MINERALS AND OXIDES • ZIRCONIUM & TITANIUM (IODIDE PROCESS) • LITHIUM METAL, CHEMICALS AND MINERALS • STRONTIUM CHEMICALS

For more information, turn to Reader Service card, circle No. 408

PRICES AND SUPPLY

TITANIUM

Sponge (99.3+%)	2.00-2.50
Bars, Rod	6.15-6.40
Plate	8.00-10.75
Sheet, Strip	6.50-11.10
Wire	7.50-8.00

ZINC

Prime Western	.10½[b]
Die Casting Alloys[a]	.15-.16
Sheet	.24
Ribbon	.21
Plates	.19

[a] Alloys 2, 3, 5. [b] Delivered price.

METAL POWDERS

Aluminum[a,b]	.40
Brass[a]	.32-.40
Copper (elec or red.)[a]	.41
Columbium	120
Molybdenum (98%)	3.80-4.10
Nickel	1.05
Tantalum	49
Tungsten (C-red. 98.8%; H_2-red. 99+%)	4-5[c]
Zirconium	
Flash Grade	11.50
Electronics Grade	15

[a] Price for —100 mesh. [c] Delivered price.
[b] Freight allowed.

OTHER NONFERROUS METALS

Cadmium (bars)	1.70
Gold	$35/troy oz
Indium (99.97+%)	$2.25/troy oz
Manganese (99.9%)	.34[a]
Palladium	$23-24/troy oz
Platinum	$84-87/troy oz
Silver	91¢/troy oz
Tantalum (sheet, rod)	55-60
Vanadium	3.45
Zirconium (sheet, strip, bar)	27-35

[a] Delivered price.

IRONS AND STEELS

Mill base prices for large quantities

SEMIFINISHED STEEL ($/net ton)

Ingots, Alloy	77
Billets, Blooms, Slabs	
Carbon, Re-Rolling	77.50
Carbon, Forging	96
Alloy, Forging	114
Seamless Tube Rounds	117.50
Wire Rods	$6.15/cwt

(continued on p 246)

For more information, circle No. 561 ➤

formica helps solve rocket thermal insulation problems

New Formica laminated plastic thermo-insulator provides protection from hot launching gases

In cooperation with Rocket Fuels Division, Phillips Petroleum Company, Formica application engineering applied Grade FF-34 (modified) with the precise characteristics for protection against hot gases.

This Formica fabricated liner protects the steel blast tube through a time cycle of intense heat in a new target drone.

This solution called for three of the Formica-4 services that assure the right laminated plastic for every requirement.

1. Application engineering to select the right grade
2. Research to adapt it to this particular application
3. Fabricating to produce a complete component ready for assembly. A fourth—Customer Stock Service—provides a ready supply of sheets and rods for prompt shipment.

This unique laminated plastics service can be of assistance to you in your own product design problems. For complete information, send for free Formica-4 bulletin 584. Formica Corporation, a subsidiary of American Cyanamid, 4550-7 Spring Grove Ave., Cincinnati 32, Ohio.

Save your engineers' time . . . use Formica-4, the complete laminated plastics service

FORMICA 4

CYANAMID

1. Application Engineering 2. Research 3. Fabricating 4. Customer Stock Service

FI-1586

How deep drawn shapes can lower unit costs

Weight...strength...appearance...reduced costs—all are part of modern, cost-cutting design for modern products. That's why Hackney deep drawn shapes and shells are outdating and replacing heavy forged, cast or welded pipe parts. For Hackney helps shape up a better product—lighter weight, stronger, more streamlined, with resistance to vibrations.

You can design from a wide range of shapes and sizes: cylindrical, spherical, conical, tapered—in capacities from a quart to 70 gallons.

These deep drawn shapes and shells have paid off in condensing units, liquid receivers, pneumatic and hydraulic products—just to name a few. Send a sketch of your plans and let Hackney engineers help you with the details. They'll be happy to consult with you on metal specifications, location of openings and fittings as you specify.

Pressed Steel Tank Company
Manufacturer of Hackney Products
1442 South 66th Street, Milwaukee 14, Wisconsin
Branch offices in principal cities
CONTAINERS AND PRESSURE VESSELS FOR GASES, LIQUIDS AND SOLIDS

For more information, turn to Reader Service card, circle No. 440

PRICES AND SUPPLY

FINISHED STEEL ($/cwt)

Form	Carbon	High Str Low Alloy	Alloy
Plate	5.10	7.62	7.20
Sheet, H.R.	4.92	7.27	—
Sheet, C.R.	6.05	8.97	—
Strip, H.R.	4.92	7.32	8.10
Strip, C.R.	7.15	10.65	—
Bar, H.R.	5.42	7.92	6.47
Bar, C.F.	7.30	—	8.77

STAINLESS STEELS ($/lb)

Material	Forging Billets	H. R. Bars	Plate	Sheet, Strip
Austenitic				
301, 302, 302B, 303, 304, 305	.38-.41	.44-.48	.46-.51	.51-.59
321[a]	.47	.56	.60	.66
347[a]	.56	.65	.70	.80
Martensitic				
410[a]	.28	.34	.35	.40
416	.29	.34	.35	.47
403	.32	.38	.40	.48
420, 440	.34	.41	.45	.62
Ferritic				
405, 430, 430F[a]	.30	.34-.35	.36-.38	.41-.47
442	.32	.38	.40	.56
431	.30	.35	.46	.54
446	.38	.45	.46	.67
High Mn				
202[a]	.37	.43	.45	.49
Extra Low C				
304L	.48	.56	.59	.63
316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	.66	.73	.85	.90

[a] Ingot prices approx 60% of forging billet price.

METAL POWDERS ($/lb)[a]

Sponge Iron	.10-.11
Electrolytic Iron	
Annealed (99.5%)	.37
Unannealed (99+%)	.36
Stainless Steel	
304	1.02
316	1.20

[a] Price for —100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 248)

How deep drawn shapes can lower unit costs

Weight...strength...appearance...reduced costs—all are part of modern, cost-cutting design for modern products. That's why Hackney deep drawn shapes and shells are outdating and replacing heavy forged, cast or welded pipe parts. For Hackney helps shape up a better product—lighter weight, stronger, more streamlined, with resistance to vibrations.

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316L	.64	.74	.78	.82
Precip Hard.				
17-7PH	.66	.73	.85	.90

[a] Ingot prices approx 60% of forging billet price.

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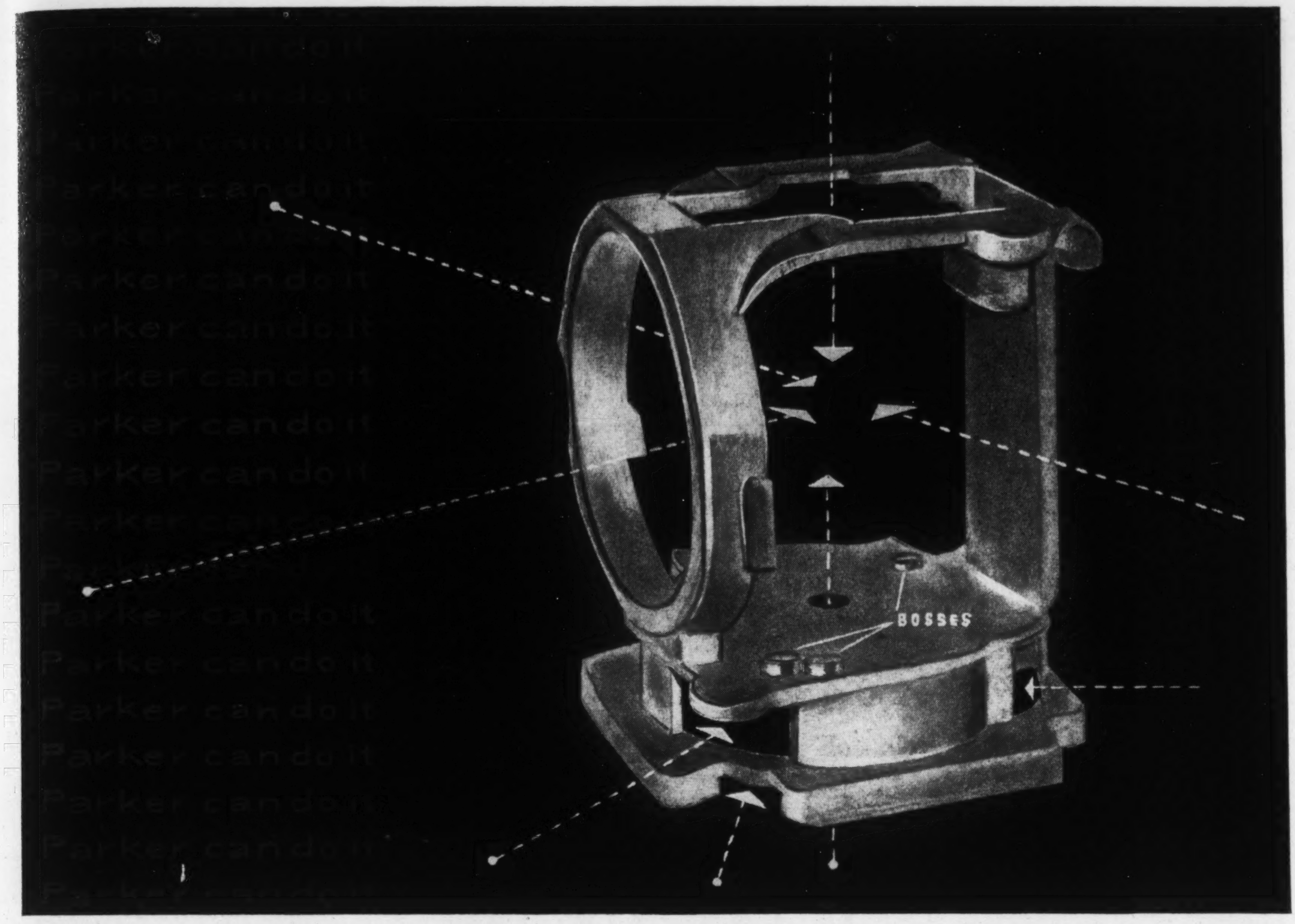
304	1.02
316	1.20

[a] Price for —100 mesh.

IRON ($/gross ton)

Pig	65-66

(continued on p 248)



Coring Too Intricate For Die Casting?

-----*not at Parker*

PARKER SALES ENGINEERS

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

CHICAGO 49, Ill.
Ollie J. Berger Company • 2059 East 72 Street

CINCINNATI 14, Ohio
William H. Broxterman • 2430 Central Parkway

DETROIT 35, Mich.
Hodgson-Geisler Co. • 18917 James Couzens

GIRARD, Penna.
Daniel F Marsh • 35 Chestnut Street

LONG BEACH 11, California
R. W. Fletcher • 2803 Loomis Avenue

PHOENIX, Arizona
Fred B. Larsen • 6108 North 11 Avenue

ST. LOUIS 8, Mo.
Frank May • 4378 Lindell Boulevard

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

WILTON, Conn.
Girard L. Palmer • Belden Hill Road

WINTER PARK, Florida
Duane P. Davis • 110 South Orlando Avenue
Box 26

Because of intricate coring—together with internal bosses—sand casting seemed to be the only way to make this part. Necessary finish machining, however, boosted costs too high.

Then Parker die casting engineers tackled the job—and licked the coring problem. The result: a part with greater density, closer tolerances, better surface finish, no finish machining and—best of all—*much lower cost per unit.*

Here is just another example of the way Parker-engineered die castings save you money.

Parker has been a leader in die casting for over 50 years—an old hand with new ideas. This skill and experience can solve problems—and save money—on *your* component parts. Just call the nearest Parker sales engineer or send your prints to the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

ADCI

LICENSED PRODUCER

PARKER

high pressure
ALUMINUM and ZINC
die castings
POWDERED METAL PARTS

For more information, turn to Reader Service card, circle No. 467

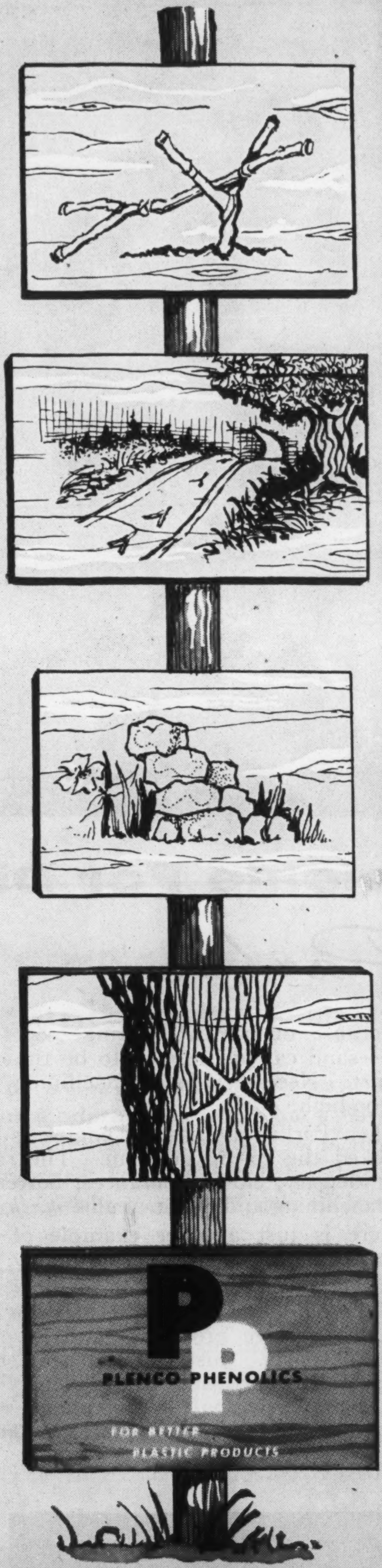
The trail is
well-marked
for
alert designers
and
manufacturers
who seek
the help of
quality
phenolic
molding
compounds

PLENCO

**PLASTICS
ENGINEERING
COMPANY**
Sheboygan, Wisconsin

Serving the plastics industry in the manufacture of
high grade phenolic molding compounds, industrial resins and coating resins.

For more information, turn to Reader Service card, circle No. 407



PRICES AND SUPPLY

CLAD STEELS (¢/lb)[a]

Cladding Metal	10%	15%	20%
Stainless			
304	37.95	42.25	46.70
304L	40.55	45.10	49.85
316L	49.35	54.70	60.10
321	40.05	44.60	49.30
347	42.40	47.55	52.80
430	29.80	33.35	37.25
Inconel	59.55	70.15	80.85
Nickel	51.95	62.30	72.70
Monel	53.55	63.80	74.05

[a] Prices given for three cladding thicknesses.

TIN PLATE ($/base box)

Hot Dip (1.25-1.50 lb)	10.05-10.30
Electrolytic (0.25-0.75 lb)	8.75-9.40

FINISHES AND COATINGS

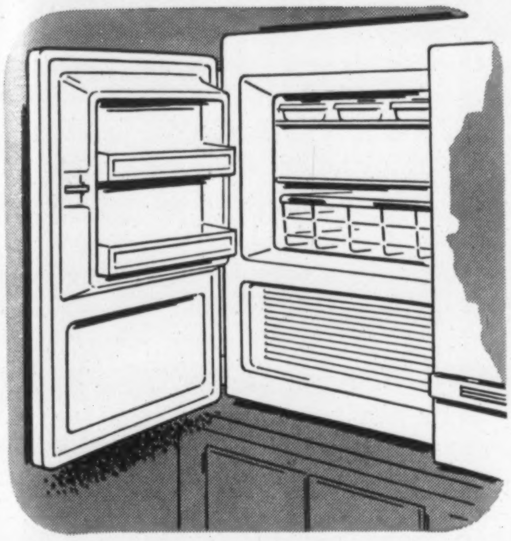
ORGANIC COATINGS

Material	Avg Thk per Coat, mil	Mils Required[a]	Cost, ¢/sq ft/dry mil[b]
VARNISHES, ENAMELS			
Short Oil Phenolic			
Varnish	1.0	1.0	1.50
Enamel	1.2	1.0	1.75
100% Phenolic	1.0	1.5	1.75
Straight Oil-Modified Alkyd	1.5	1.5	1.50
Alkyd-Amine (90-10)	1.5	1.5	1.75
Alkyd-Phenolic (50-50)	1.5	1.5	1.75
Alkyd-Vinyl (50-50)	1.0	2.0	2.0
Alkyd-Styrene (70-30)	1.2	1.5	1.75
Epoxy	1.8	1.8	2.00
Silicone	.5-1.0	.5-1.0	6.0
Furane	2.0	2.0	1.0
Neoprene	5.0	5.0	1.50
DISPERSION COATINGS			
Phenolic	1.0	1.5	1.75
Vinyl	1.0	2.0	2.50
Fluorocarbon	1.0	1.0	15.0
LACQUERS			
Nitrocellulose	1.0	2.0	2.50
Vinyl	1.0	2.0	2.50
Acrylic	1.0	2.0	2.75
Butyrate	1.0	2.0	2.75

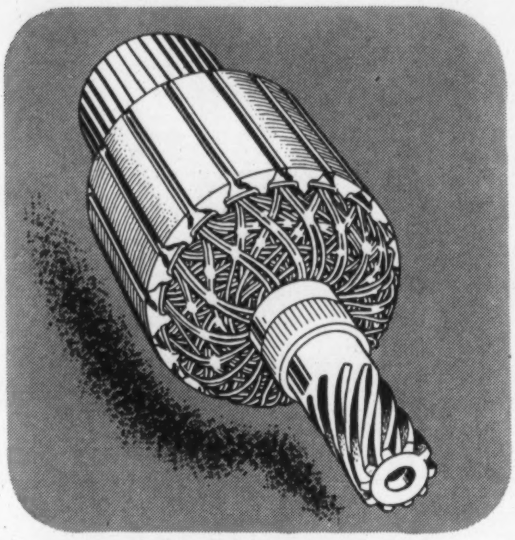
[a] Thickness over phosphate coating required for exterior durability on steel. For purely decorative coating, 1 mil will usually suffice.
[b] Materials cost only. Realistic price comparison can be made only on basis of dry applied coating, not on basis of cost per gallon.

(news on p 250)

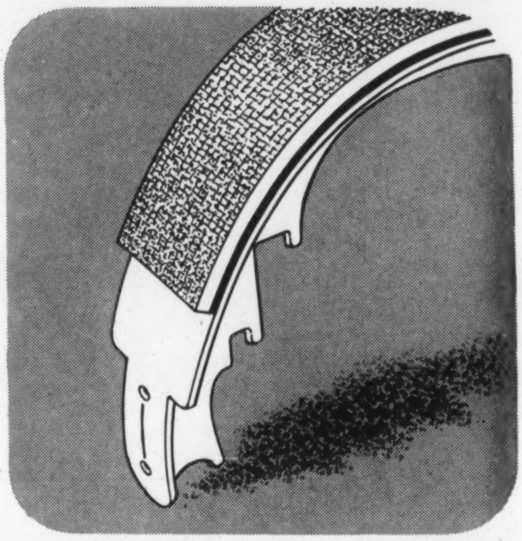
You can save time and money with R/M Ray-BOND® Adhesives



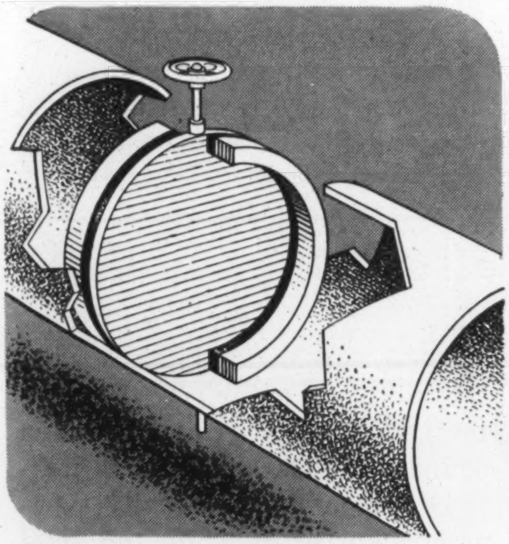
Bonding laminated panels of all-plastic refrigerators



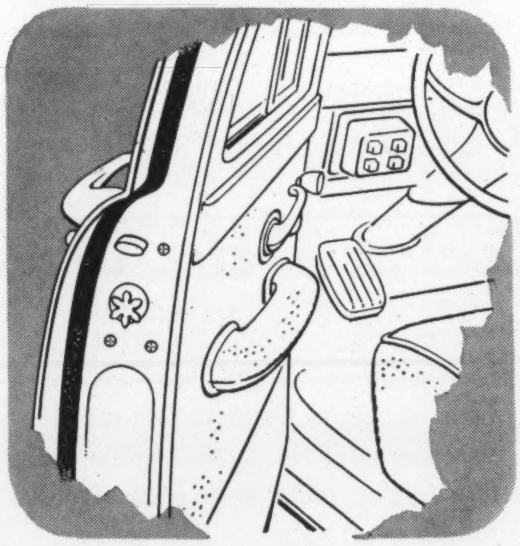
Bonding, sealing, protecting armature coils



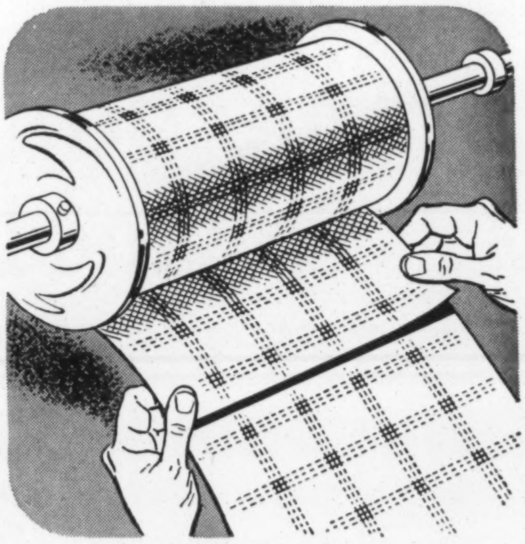
Bonding friction materials to metal



Bonding rubber seals to valve gates



Bonding sealing strip to car door



Bonding textile to textile

FOR THESE AND COUNTLESS OTHER APPLICATIONS NEW R/M RAY-BOND ADHESIVES CAN BE TAILORED TO YOUR NEEDS

Modern bonding techniques can simplify and improve product designs and eliminate troublesome production fastening operations. Shown above are a few applications which may suggest where R/M Ray-BOND adhesives, protective coatings, and sealers can have important advantages for you—*whether or not* bonding, laminating, sealing or coating are now factors in your operations.

From more than 20 years of experience in the production of bonded assemblies, R/M has acquired a wealth of experience in developing adhesive products to save time and money in varied applications. Call on our engineers to work with yours in finding new ways to cut costs and simplify production. Adhesives Department, RAYBESTOS-MANHATTAN, Inc., Bridgeport, Conn.

R/M Bulletin No. 650A contains engineering information you will want on Ray-BOND adhesives, protective coatings and sealers. Write for your free copy.

RAYBESTOS-MANHATTAN, INC.

ADHESIVES DEPARTMENT: Bridgeport, Conn.

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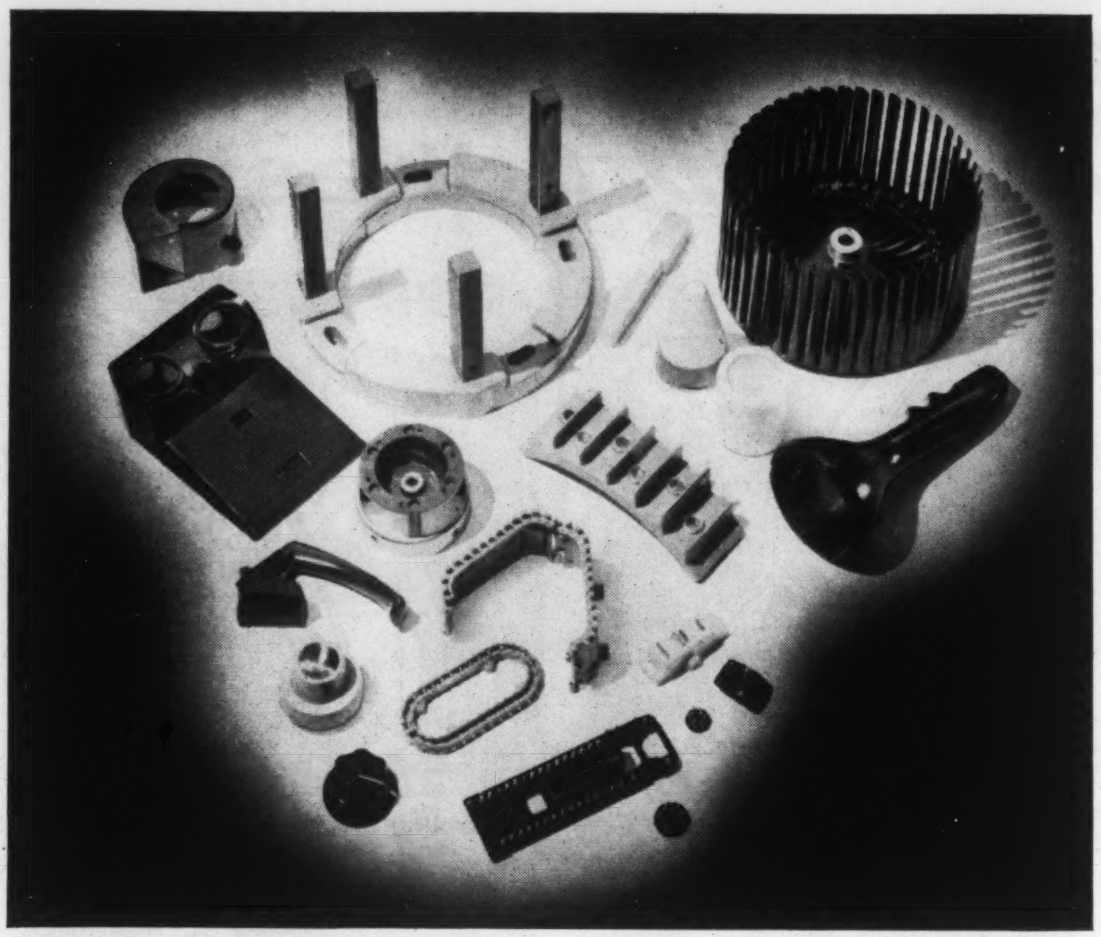

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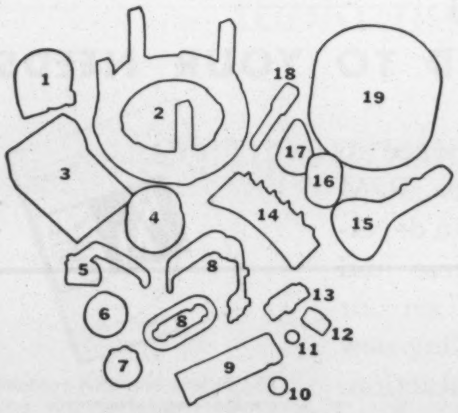

1. impeller housing. **2.** rocker ring. **3.** stereo viewer. **4.** fuse nose. **5.** appliance handle. **6.** and **7.** knobs. **8.** and **9.** terminal boards. **10.**, **11.**, and **12.** miniaturized parts. **13.** organ key. **14.** terminal board. **15.** spinning reel handle. **16.** valve liner. **17.** fuse nose. **18.** organ key. **19.** blower wheel.

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Interim Report—cont'd from p 241

Steel—In spite of a 4% increase in the price of steel, consumption in 1957 is expected to be quite high. One observer estimates a 4% increase over 1956. Production is expected to reach the record high of 117 million tons registered in 1955. Price of steel should remain fairly steady, at least until next summer.

Production, Use of New Polyethylene Up

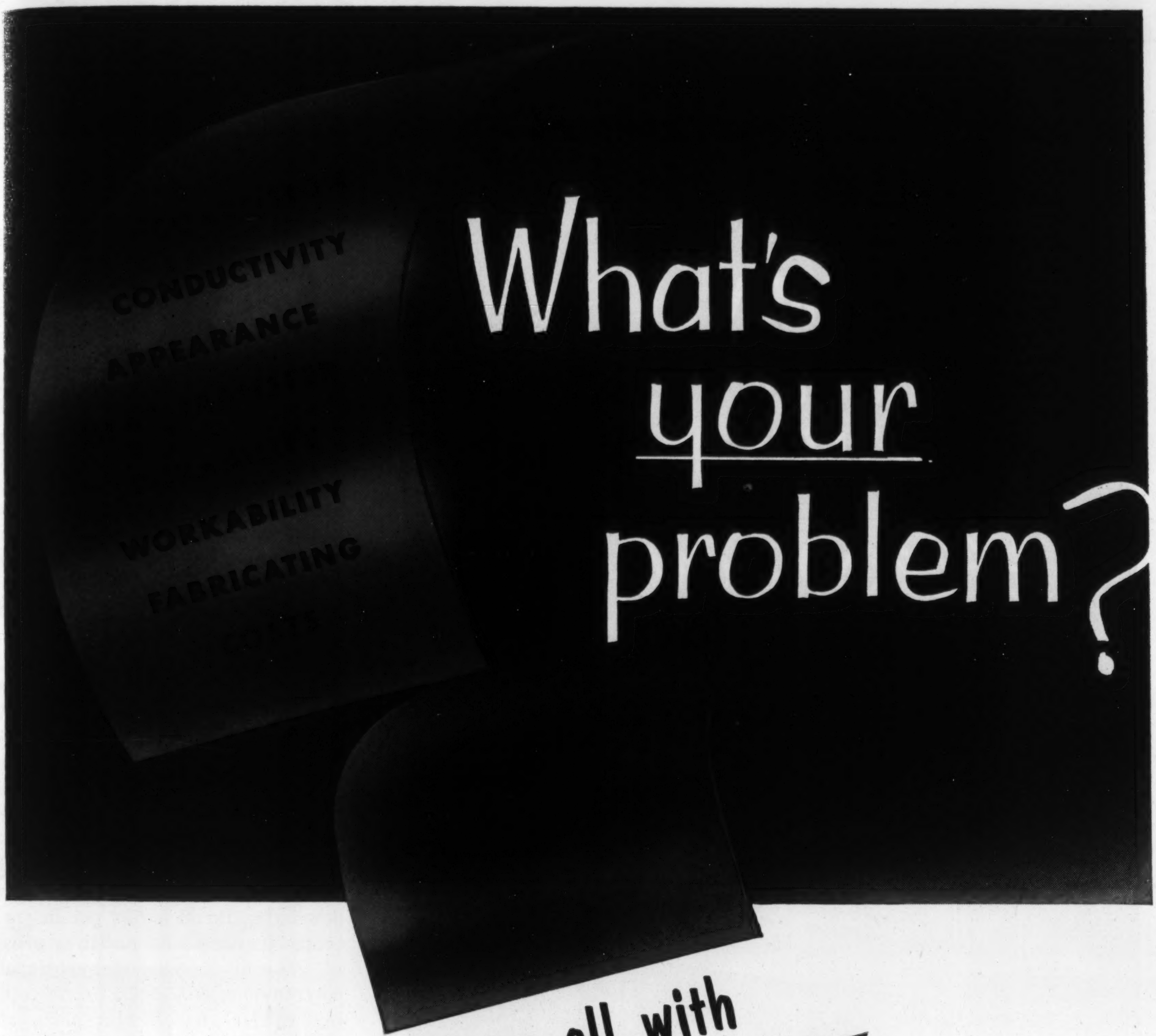
Production and consumption of high density (low pressure) polyethylene will increase considerably during the next few years, according to Dr. Robert S. Aries, Aries Associates. Speaking at a recent meeting of the American Chemical Society, Dr. Aries pointed out that rated capacity for all types of polyethylene for the year 1958 is set at one billion pounds, and market research indicates the new high density types will comprise 30% of the total capacity. Actual production, however, is estimated to be about 760 million pounds, with 18% of it being high density material.

By 1962, production of all polyethylene is expected to climb to about 1.1 billion pounds, with the high density material accounting for 39% of the total. Projected end uses of both types by 1962

1962 CONSUMPTION OF HIGH AND LOW DENSITY POLYETHYLENE[a]
(Millions of Pounds)

End Use ↓	High Density	Low Density
Molded Articles	120	100
Electrical	45	75
Film	100	250
Pipe	30	110
Paper Coating	35	55
Bottles, Tubes	25	75
Fibers	25	—
Misc, Exports	60	40

[a] Estimated.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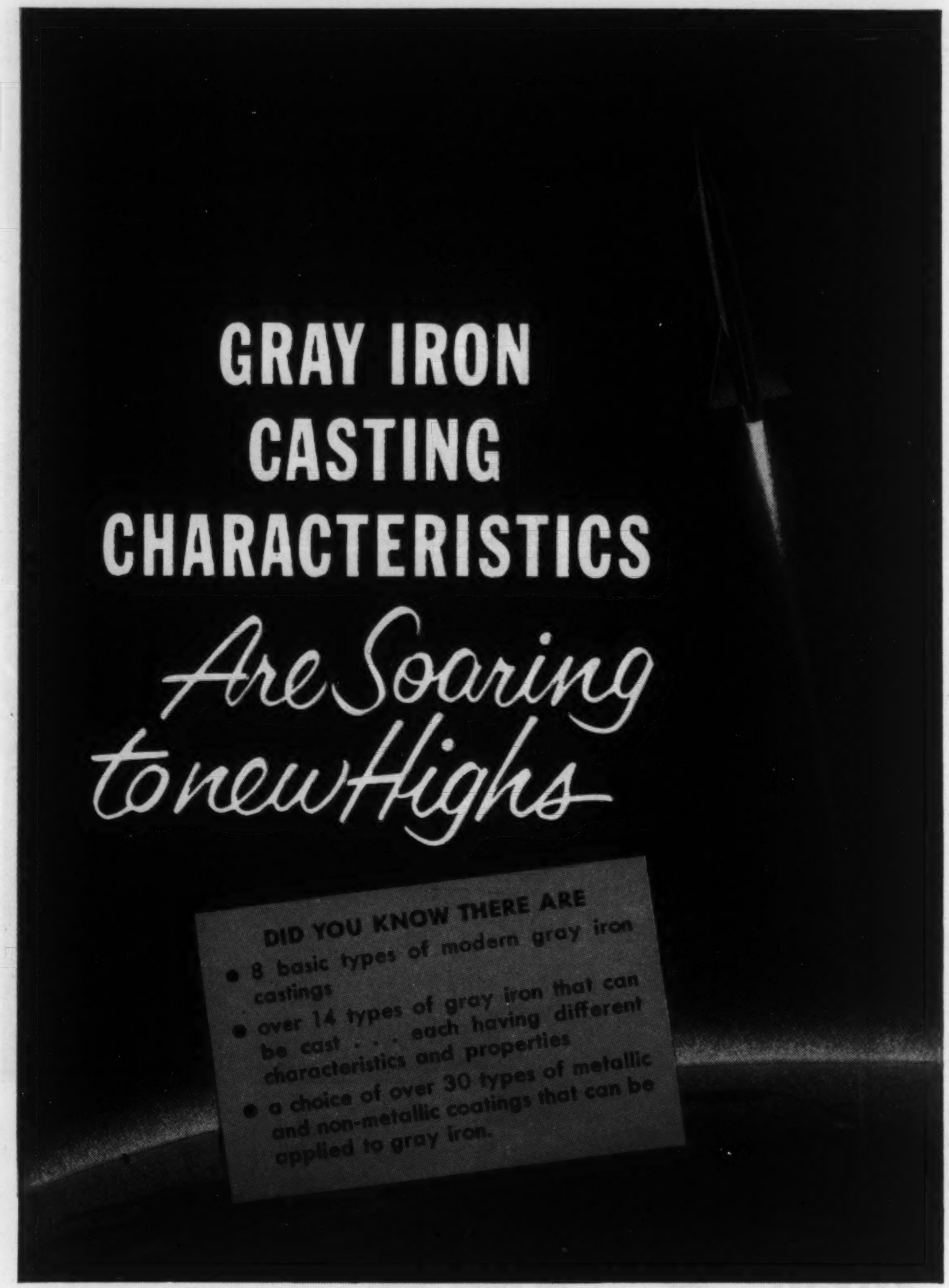
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are indicated in the accompanying table.

Four processes are currently used to produce high density polyethylene: Ziegler, Phillips, Standard Oil of Indiana and R. S. Aries. In 1958, there will be at least eight commercial producers of various types of high density polyethylene in the U. S. And at least seven other companies are said to be engaged in development work aimed at selecting a process for the production of high density polyethylene. (There are presently nine producers of the branched low density type.)

Effect on price

According to Dr. Aries, this "is the first time in the industry that there has been such a large productive capacity entering the market in such a short time." As a result, by 1961 the price of the new material is expected to decrease to the level of conventional polyethylene. Present price of high density material is 53¢ per lb (recently increased 3¢ per lb); price of general purpose conventional polyethylene is 35¢ per lb. According to Dr. Aries, the price of high density polyethylene will decrease to around 31¢ per lb by 1961.

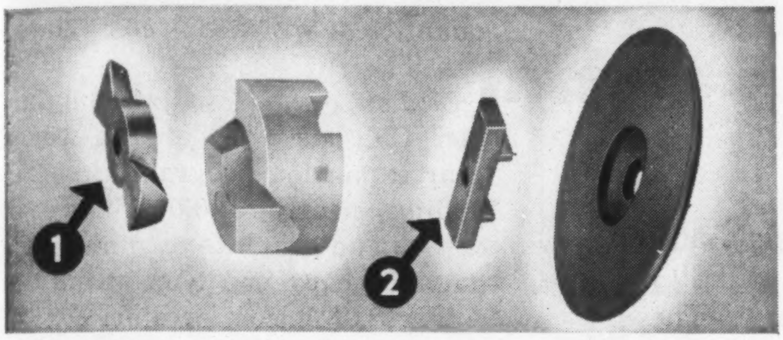
According to Dr. Aries, the new polyethylene will not offer much competition to conventional material, since their properties are so different. Instead, the new plastic is expected to replace glass, metal and wood for many applications and, to a lesser extent, other plastics such as phenolic, nylon and high impact polystyrene.

What's Happening in Prices and Supply

Phenolic—A 1¢-per-lb price increase for phenolic molding materials, resins and laminating varnishes has been announced by both Bakelite Co. and General Electric Co. General purpose, standard

MEETING DESIGN NEEDS

BRASS POWDER FORMS IMPORTANT CONNECTION FOR WESTERN ELECTRIC



The Clutch Coupling (1) and Bar Coupling (2), shown above, function with two insulators to form an important drive linkage in Western Electric's "lineman's test set". These BRASS POWDER parts perform the dual role of activating a signaling generator and retaining a molded nylon cam that insulates the handle up to 10,000 volts.

The complex, curved surfaces on the blades of the Clutch Coupling would be very difficult and expensive to machine from bar stock. For this reason, Western Electric designed both of these parts for the powder metal process and turned the job over to an experienced fabricator*. Thus, unit cost was very low, high performance standards were met and much valuable machining time was saved.

Consult with a metal powder fabricator when you have difficult design problems—or when you simply want to lower your production costs with BRASS POWDER sinterings.

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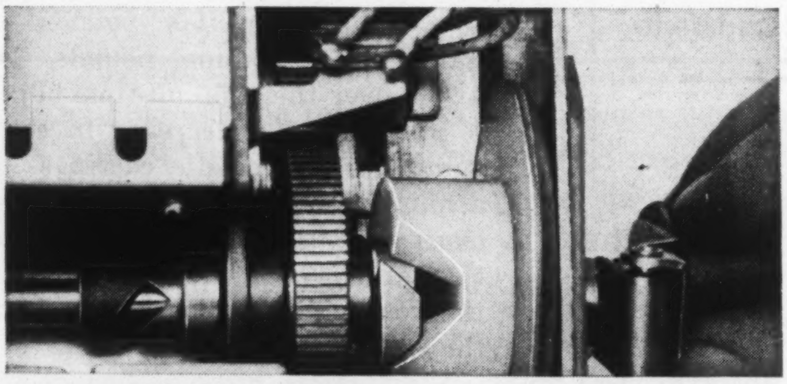

Detail of the Clutch Assembly on Western Electric's signaling generator. The Bar Coupling turns the Nylon Cam which pushes the Clutch Coupling forward to engage the drive gear.

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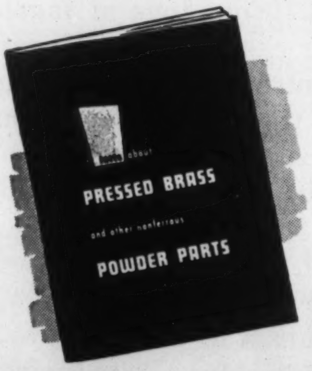

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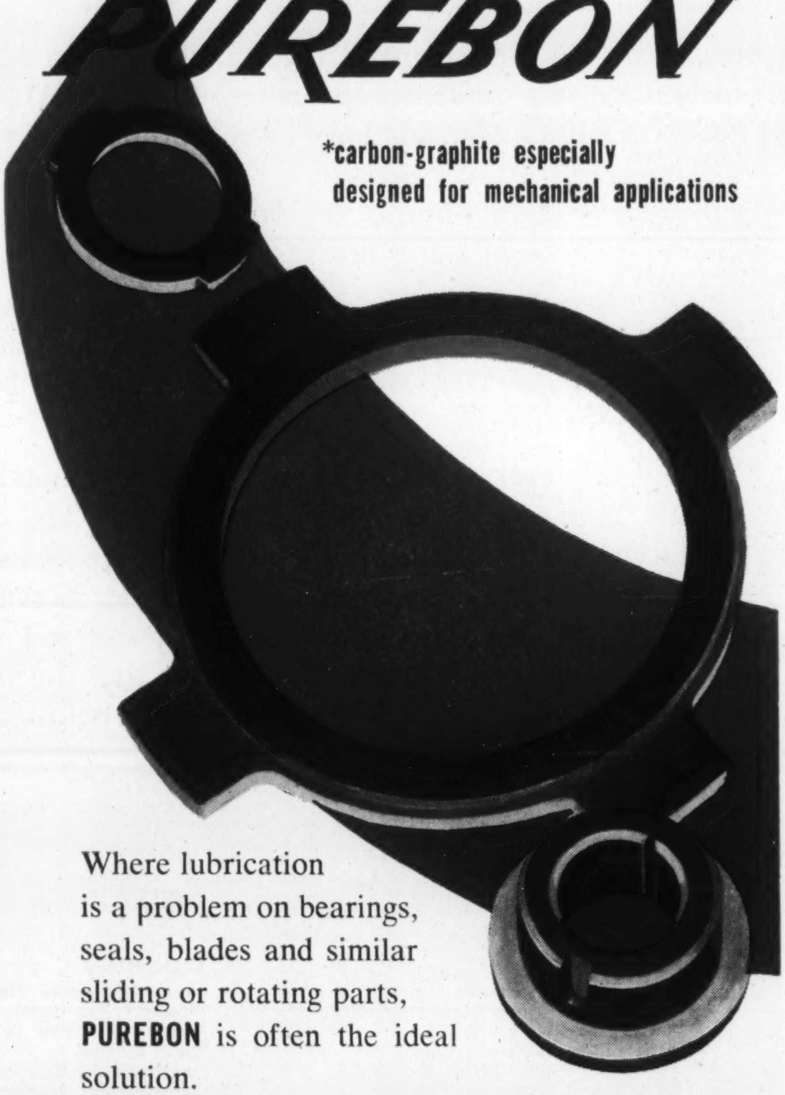

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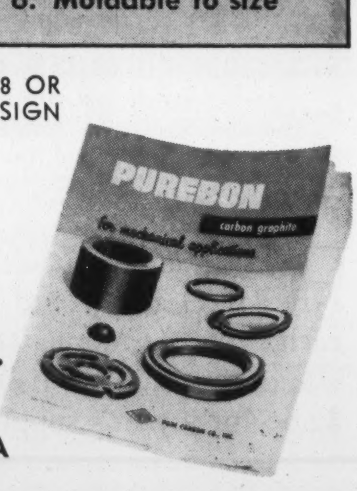

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molding compounds in truckload quantities will now cost 21½¢ per lb.

Carbon, graphite—National Carbon Co. has completed a seven year expansion program aimed at adding nearly 100,000 tons of carbon and graphite to annual production capacity. According to Adger S. Johnson, president, "For the first time in a number of years we now have sufficient productive capacity to take care of industry's normal anticipated requirements . . . for several years to come."

Nylon—Price reductions of from 5 to 7% on nylon rod and other nylon stock shapes have been announced by Polymer Corp. of Pennsylvania.

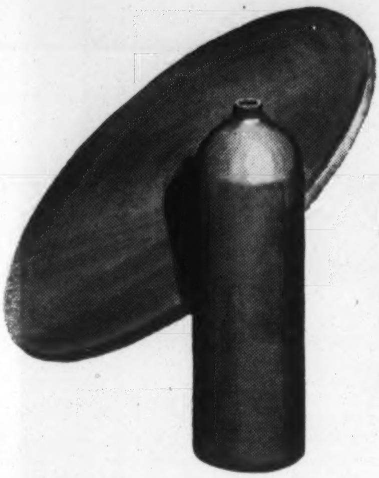
Die castings—Latest figures released by the American Die Casting Institute reveal that 1957 will again see a new high in aluminum die casting consumption. Expected total is 385 million pounds—a gain of 18 million pounds, or 4.9%, over the 1956 all-time high.

In spite of a decrease in consumption of zinc die castings in a number of major areas, indications are that the total consumption of zinc for die castings for the year will be at least equal to the 362,500 tons used in 1956.

Steel—More steel was made in the first eight months of this year than in any previous eight month period in this country, according to American Iron and Steel Institute.

The record eight month total was 78,710,279 net tons of ingots and steel for castings. The largest previous figure was 76.6 million tons during the first eight months of 1953. Last year, first eight month output was about 72.3 million tons.

Mr. J. M. Curto, U. S. Steel Corp., predicts that 4% more steel will be consumed in 1957 than was used in 1956. Mr. Curto points out that in spite of the currently low operating rate, studies indicate that actual consumption of steel is at a record level.



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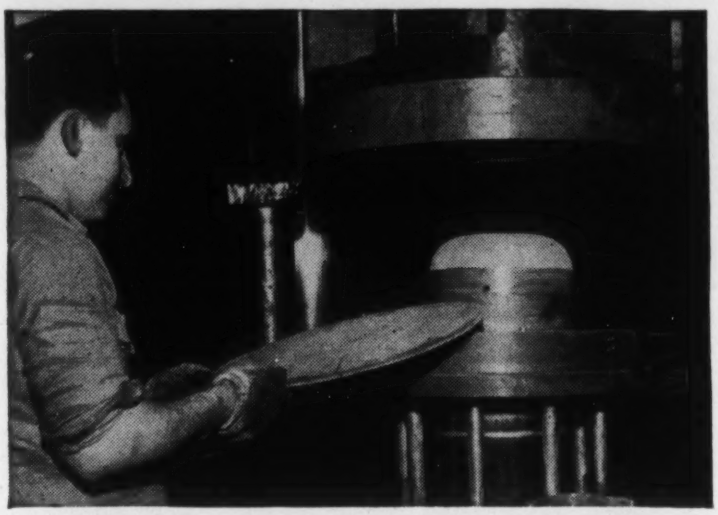
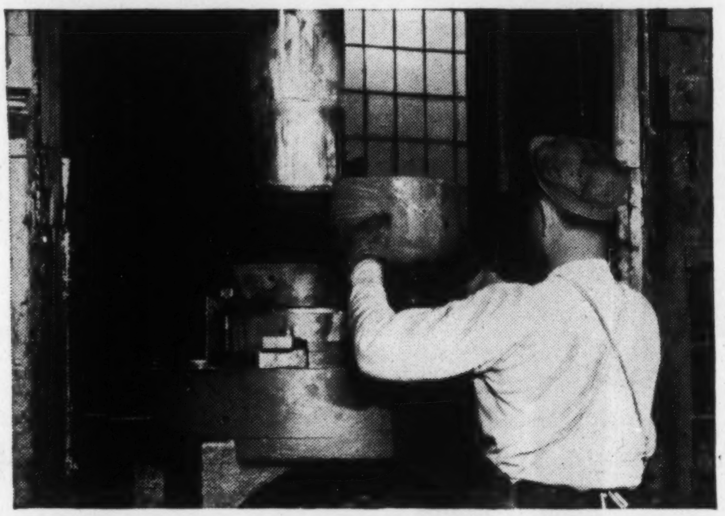
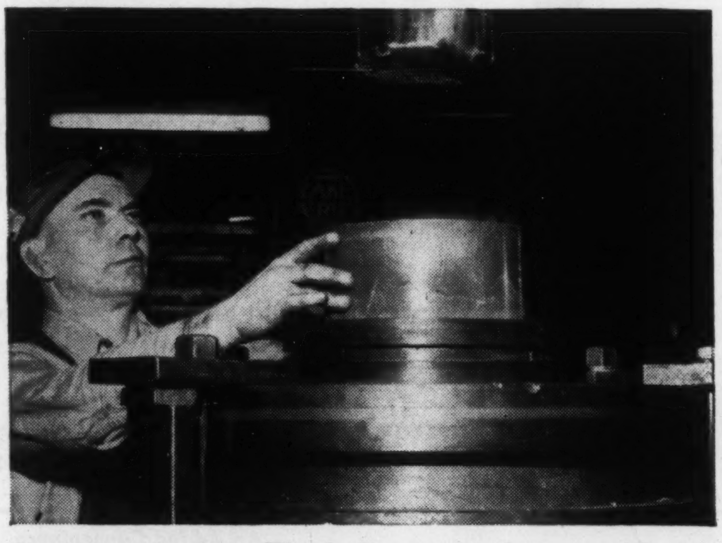
BONDERITE AS AN AID IN COLD FORMING



Cupping: Flat CO_2 cylinder blank, treated with Bonderite and Bonderlube, is changed into cylindrical form, with maximum of about 45% reduction in diameter of blank.



First reduction: Diameter of cup is made smaller and length increased without major change in wall thickness.



Second reduction: Final diameter of part with respect to length determines number of reductions required. Photos courtesy NORRIS-THERMADOR Corporation, Los Angeles, California.

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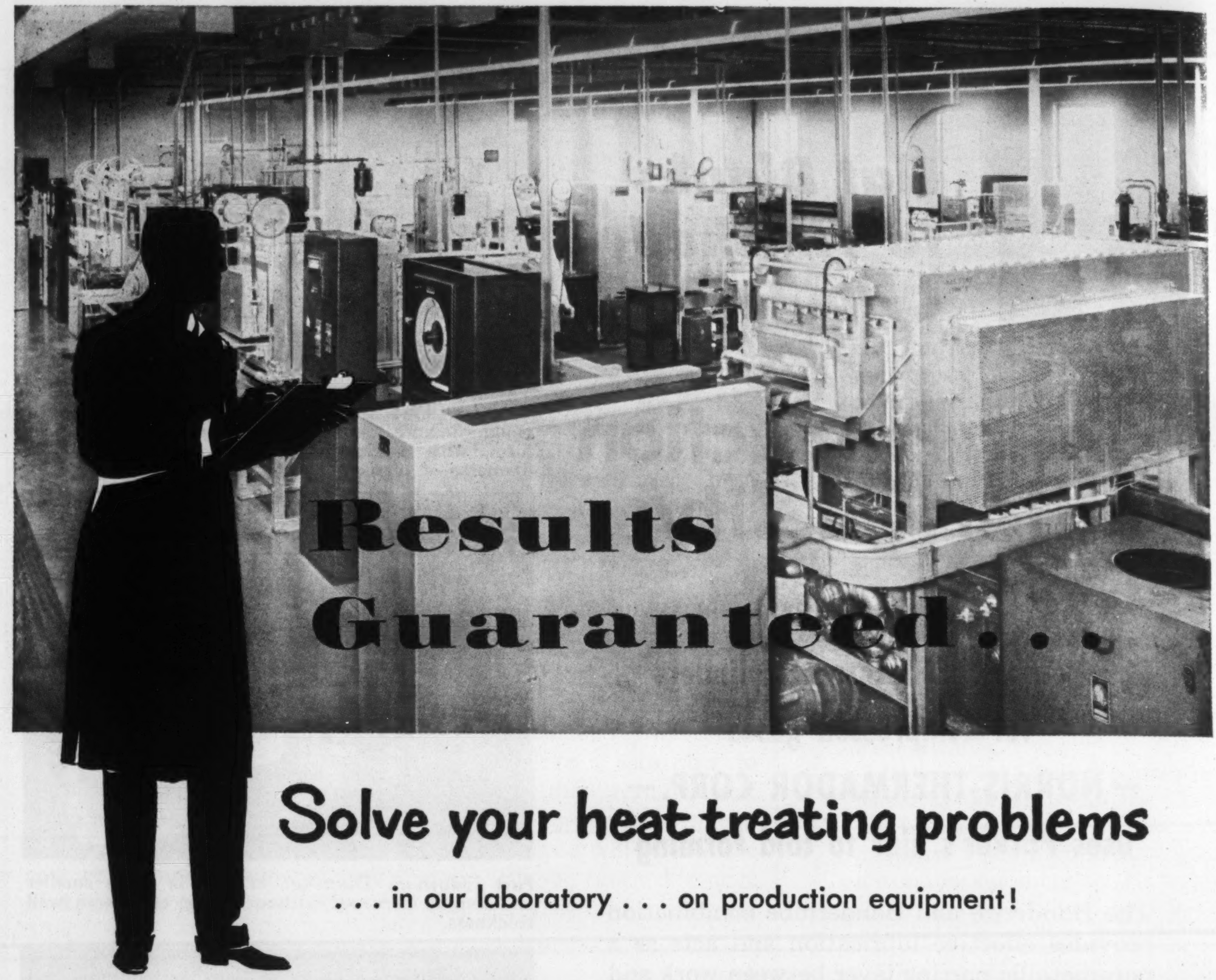

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News OF INDUSTRY

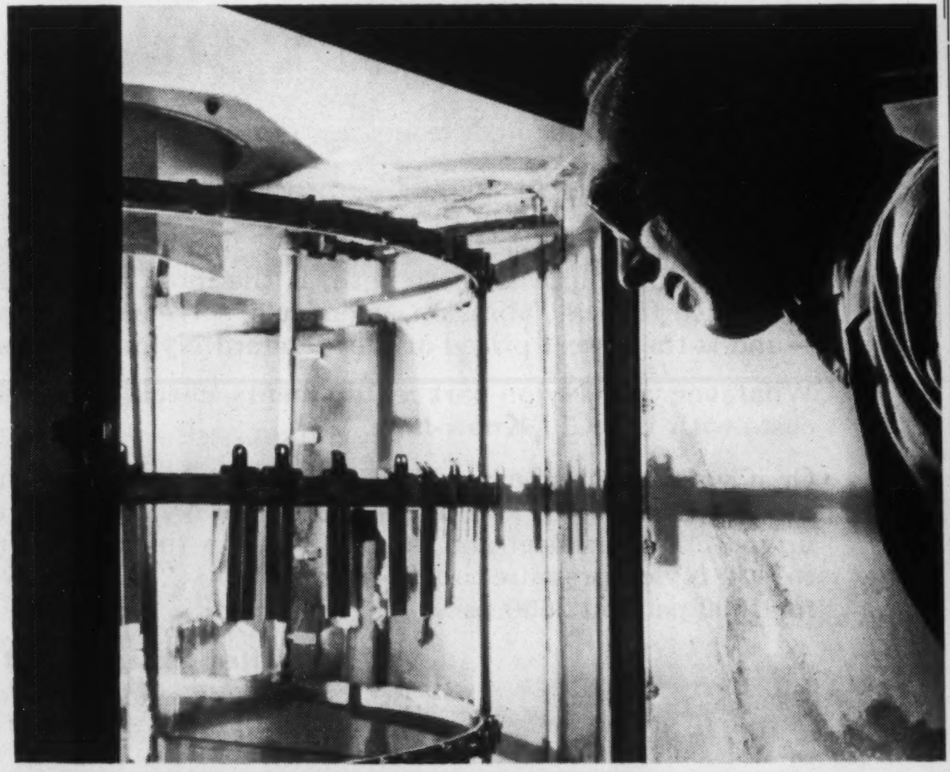
Rubber Lab to Study New Materials, A-Radiation

U. S. Rubber Co. recently announced that it has begun a five year research and development program aimed at 1) developing a passenger car tire of "such superior quality" that it would eliminate the necessity for spare tires; 2) producing materials that will provide a range of hardness, toughness and stretchiness all the way from rubber to metals; and 3) utilizing atomic energy for the development of new and better rubber and plastics materials.

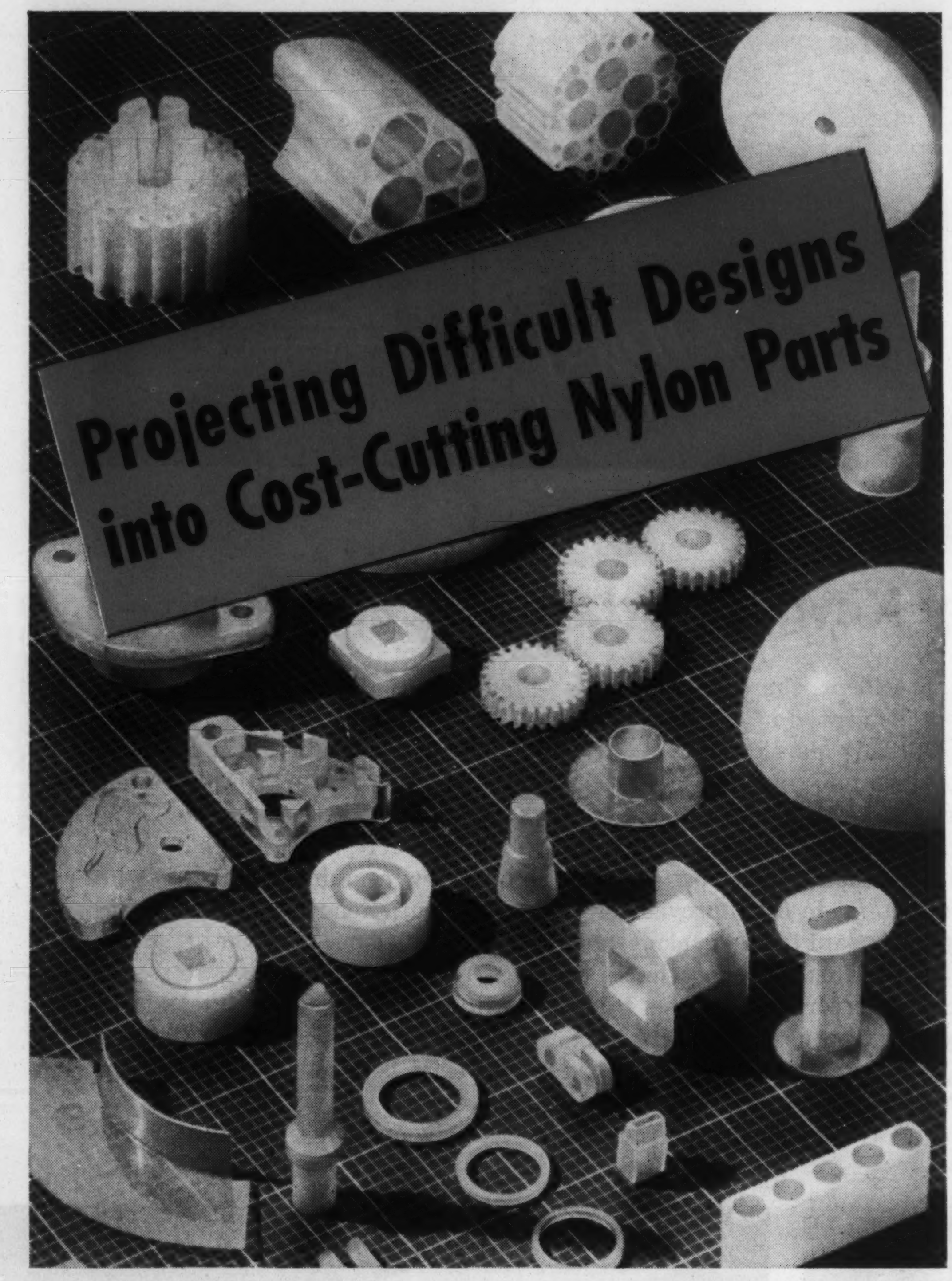
According to H. E. Humphreys, Jr., president, the company's new research center in Wayne, N. J., has already developed three new experimental tires. One of the tires, made of polyurethane rubber, is claimed to give 200% more mileage than tires now in use. Another, made of improved butyl rubber, is said to add considerably to the comfort and smoothness of a car's performance. The third, made of silicone rubber and wire, is said to withstand sustained temperatures up to 500 F. The silicone tire is designed for use on supersonic aircraft; the rubber formulation is claimed to be the only rubber-like material that can withstand such temperatures and still retain elasticity.

A rubber-plastics blend, based on a new combination of acrylonitrile, butadiene and styrene, has been developed by the research center for use as a hot water pipe. Although further development work is necessary before the new material is ready for use in home plumbing, its properties are extremely encouraging: it is light-

Progress in tire research *is evident by development of three new experimental tires: from left to right, tires are made of butyl, polyurethane, and silicone and wire.*



Effects of weather *on rubber are tested in new lab by using this weatherometer which creates "sunshine and rain."*



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Or if your requirements are extruded stock—U.S.G's new ultra-modern Extrusion Plant offers *bubble-free* Nylon rod in diameters up to 3"; Nylon sheet and tape 12" wide in thicknesses from .002" to 1/8"; Nylon pressure tubing from 1/8" to 1/2" O.D. in two types—for 1000 psi and 2500 psi.

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weight, resists chemical attack and swelling, and retains strength even at temperatures as high as 220 F. At 160 F, the material is said to offer twice the strength of standard pipe plastics.

Atomic radiation is already being used to cure rubber. However, according to Mr. Humphreys, "We see a flood of new materials . . . resulting from atomic energy. We see entirely new processes, in which atomic energy does the work of heat, pressure, catalysts and chemicals. And we are seeking to develop special types of rubber which will stand up under atomic rays at atomic energy plants."

U. S. Rubber is experimenting with atomic energy at the new center with a two-million-volt electron accelerator. It also plans to share with nine other companies a nuclear reactor now being built at Plainsboro, N. J.

Altogether, U. S. Rubber plans to spend a minimum of $120 million over the next five years on research and development and, according to Mr. Humphreys, "We expect . . . our new research center . . . to set the pace for the future."

Three Producers Form Largest Titanium Mill

What is claimed to be the largest integrated titanium mill in the United States has been formed by P.R. Mallory & Co., Inc., Sharon Steel Corp. and National Distillers & Chemical Corp. According to J.A. Roemer, president of Mallory-Sharon, the new operation will be capable of melting 12 million pounds of titanium per year. Last year the entire titanium industry shipped 10 million pounds of finished mill products.

The merger will work this way: Mallory-Sharon Titanium Corp. (now owned jointly by P.R. Mal-

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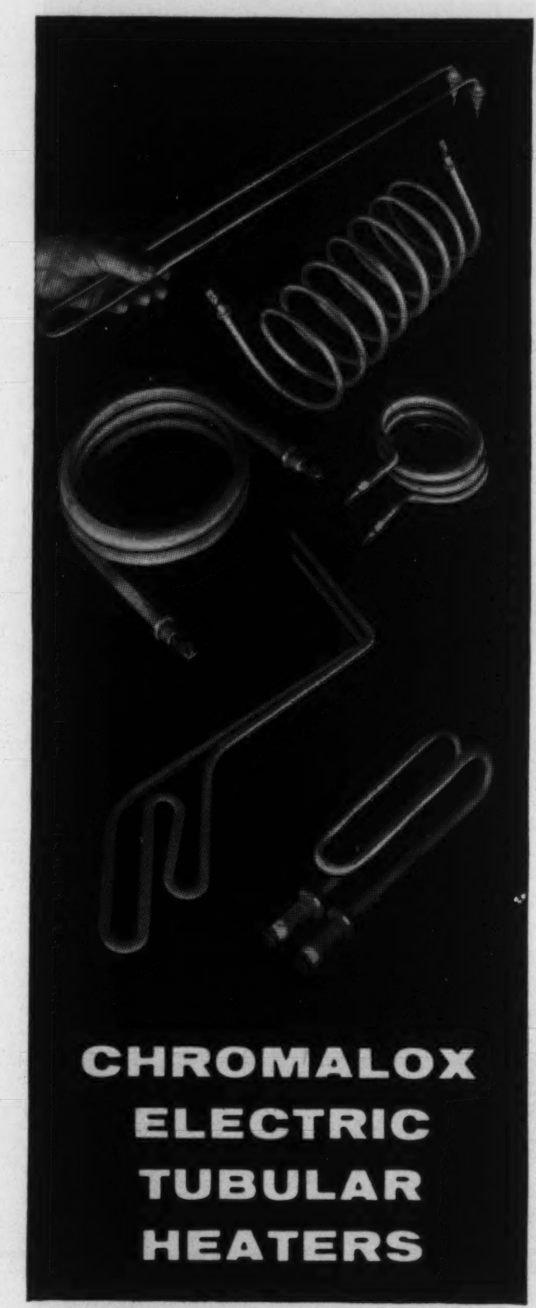

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CHROMALOX

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lory and Sharon Steel) will acquire all of the titanium and zirconium production facilities of National Distillers, plus the entire ownership of Reactive Metals, Inc. (now jointly owned by National and Mallory-Sharon). Next Mallory-Sharon will change its name to Mallory-Sharon Metals Corp. The new corporation will then be owned one-third each by National Distillers, P.R. Mallory and Sharon Steel.

High Purity Iron Aim of Battelle Study

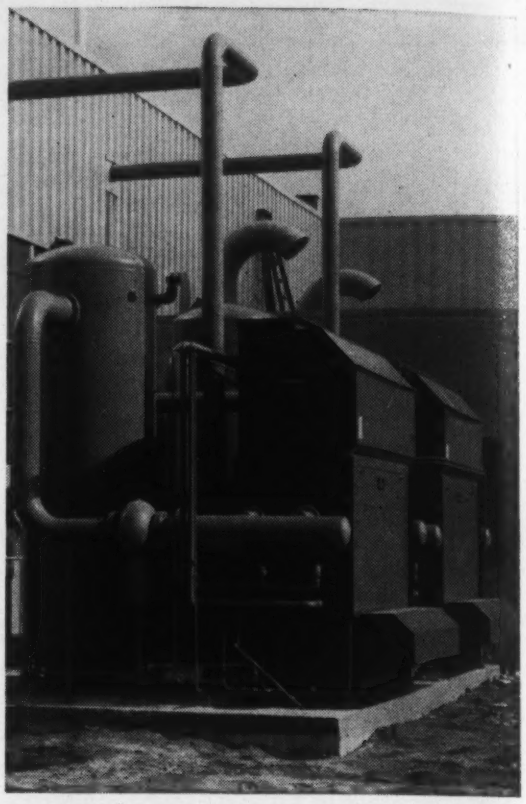
For the ninth year in succession, the American Iron and Steel Institute is underwriting a special program at Battelle Institute aimed at production of purer iron through better purification methods.

Two possible preliminary purification methods to be considered are direct zone purification of high oxygen electrolytic iron and vacuum melting of electrolytic iron with carbon. According to Dr. George W. P. Rengstorff, head of the program at Battelle, a supply of 1-lb ingots of zone purified iron will be maintained for distribution at the direction of AISI.

New Division in SPI to Cover Epoxy Resins

The Society of the Plastics Industry, Inc. has established a new division which will be primarily concerned with advancing epoxy resin technology. The new division, known as Epoxy Resin Formulators, will cover electrical, tooling and adhesives fields.

Ultimate aim of the new SPI division is the development, in cooperation with other groups, of specifications, chemical and physical test procedures performance standards and testing programs



This Niagara Aero After Cooler also cools compressor jacket and intercooler water.

COMPRESSED AIR
- **Lower in Cost**
- **Drier and Cooler**

THE NIAGARA *AERO* AFTER COOLER offers a completely self-contained method replacing both shell-and-tube cooler and cooling tower. It is independent of a large supply of cooling water and consistently reduces compressed air temperatures to below ambient.

Drier air gives you better operation and lower costs in using all air-operated automatic instruments, tools and machines, paint spraying, sand blasting and moisture-free air cleaning.

Direct saving in the cost of cooling water saves the price of the Niagara *Aero* After Cooler in less than two years.

Niagara *Aero* After Cooler assures all these benefits because it cools compressed air or gas below the temperature of surrounding atmosphere; there can be no further condensation in your air lines. It condenses the moisture by passing the air through a coil on the surface of which water is evaporated, transferring the heat to the atmosphere. It is installed outdoors, protected from freezing in winter, proven in service on the largest plant utility systems.

Write for Bulletin No. 130

NIAGARA BLOWER COMPANY
Dept. MM-11, 405 Lexington Ave.
NEW YORK 17, N. Y.
District Engineers in Principal Cities of U. S. and Canada

For more information, circle No. 469

Remove Rust

in 2 SIMPLE STEPS... *without acids*

1. Just DIP...
2. Then RINSE!

with Turco Alkaline Rust Remover

PHOTOGRAPH COURTESY AXELSON MFG. CO.

THE CHOICE IS YOURS!

Here's a single-tank process that *completely obsoletes* conventional methods of removing rust, paint and primer. With Turco Alkaline Rust Remover, you just *dip*, then *rinse!* That's all there is to it!

An easy-to-handle, powdered material, Turco Alkaline Rust Remover normally strips slightly pitted rust in less than a minute. Heavy rust and multiple paint layers require only a few minutes' immersion. Turco Alkaline Rust Remover requires no after-neutralization... no electrolytic current. It contains no cyanide compounds... emits no corrosive fumes. Moreover, it does not affect dimensional tolerances, cause hydrogen embrittlement, or create any of the other hazards commonly encountered with acids. Since Turco Alkaline Rust Remover actually *decreases* the tendency of metals to re-rust, the need for subsequent rust preventive treatments is virtually eliminated.

Turco Alkaline Rust Remover has been thoroughly *proven* in the laboratory... exhaustively *tested* in the field... and *universally accepted by industry!* Check this *new* way... this *better way*... to beat back the problem of rust!

QUICKLY REMOVES TENACIOUS HEAT SCALE, TOO!

Now... with Turco Alkaline Rust Remover used electrolytically, tenacious heat scale can be *quickly* and *completely* removed... with no dimensional loss to the base metal. Moreover, the descaled metal surfaces are exceptionally clean, shiny and free from smut, with a minimum tendency to re-rust.

the obsolete method of rust and paint removal	the TURCO method of rust and paint removal
1. Dip for alkaline degreasing and paint removal	1. Dip for rust and paint removal plus rust prevention
2. Rinse	2. Rinse
3. Acid dip for rust and red oxide removal	
4. Rinse	
5. Neutralize	
6. Rinse	
7. Dry	
8. Dip for rust prevention	

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RUST
REMOVER

FREE FOLDER
TELLS HOW — Write today for free 4-page illustrated folder describing Turco Alkaline Rust Remover — the *non-acid* compound that quickly removes rust, paint and primer in two simple steps.

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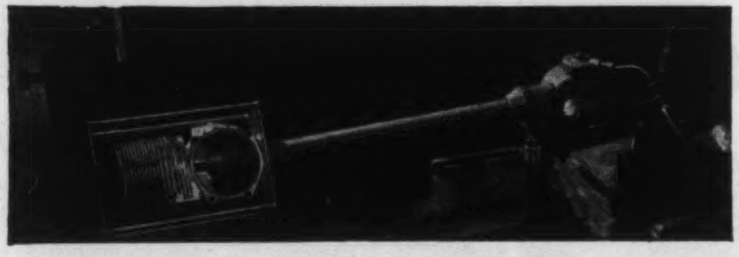
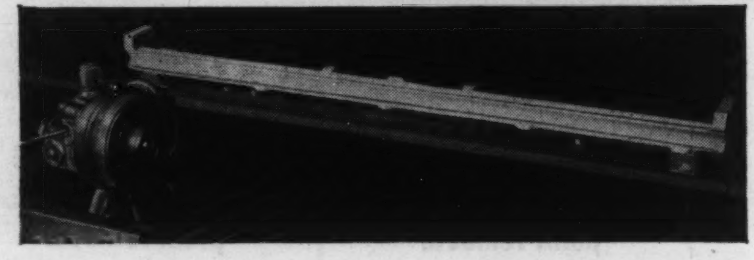
Light weight, hard-faced aluminum and magnesium outwear steel

Molybdenum, steel or stainless sprayed coatings, applied at high speed and low cost, offer many opportunities for product improvement.



Inside cylinder wall of portable gasoline engine being sprayed with molybdenum. Part showed little or no wear after 4,000-hour test run. Chrome-plating broke down in less than 400 hours.

Aluminum torque tube, used in control of aircraft trim tabs, being hard-surfaced at end bearing sections. Molybdenum is used on these press-fit bearing sections and build up to required dimension completed with hard stainless steel.



This accounting-machine undercarriage —made of aluminum for light weight— is being hard-surfaced by metallizing with steel.

A wide range of hard metals, including molybdenum and hard stainless steel are being applied to light weight metals to provide even longer service life than is possible with solid steels, yet retaining the weight-saving advantages.

Application is relatively simple—fast, modern metallizing guns will spray over 20 pounds of stainless steel per hour. This, in the comparatively thin coatings used, usually ranging from .003" to .010", spells high-speed surface coverage. Semi-automatic control equipment is available for production line operations. Free operator training and on-the-spot service is supplied by full-time, company-trained, field engineers.

For further information send off the coupon attached or even better, write, giving us some idea of the application you have in mind.

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METALLIZING EQUIPMENT COMPANY, LTD.—Chobham near Woking, England

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TITLE ____________________

COMPANY ____________________

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covering epoxy compounds used for industrial and consumer applications.

Members of the new section are: Armstrong Products Co.; Furane Plastics, Inc.; Houghton Laboratories, Inc.; Kish Industries, Inc.; Mainland Plastics Co., Inc.; Marblette Corp.; Permacel Tape Corp.; Ren Plastics, Inc.; Rezolin, Inc.; and U.S. Gypsum Co.

Metal Powder Parts Get Another Name

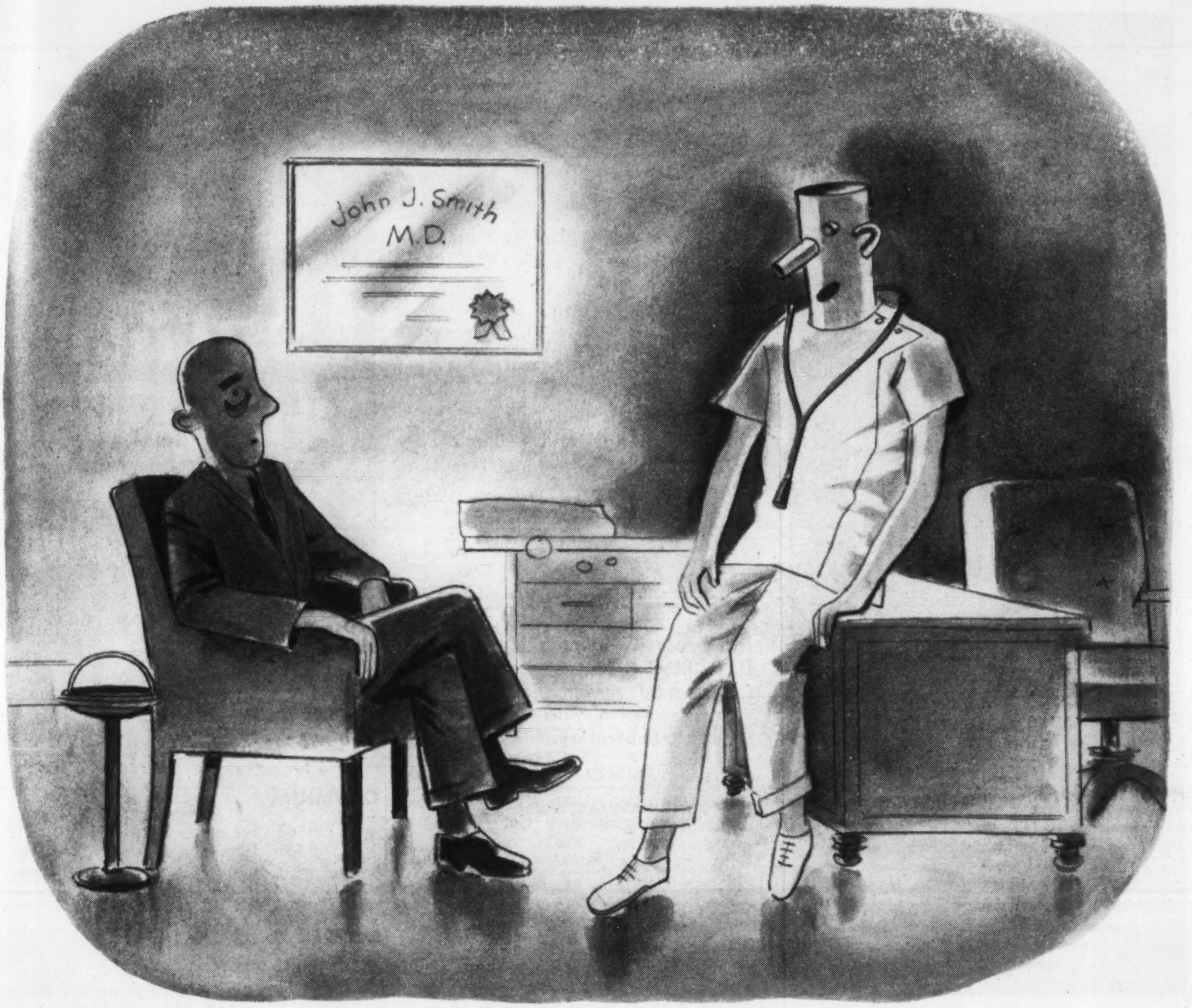
"Powder-metallurgy parts" has officially replaced "sinterings" as the product designation for the structural and bearing units produced by the 18 member companies of Powder Metallurgy Parts Manufacturers Assn.

According to a spokesman for the group, the main reason for the change is that "sintering is only one specific process among the many phases of production that are required to transform metal powder into . . . a part." (For comment on this name change, see MATERIALS IN DESIGN ENGINEERING, Oct '57, p 336.)

'Shots' for Trees Aid Cellulose Research

By means of an ordinary hypodermic syringe, a dose of radioactive carbon 14 was recently injected into the trunk of a small pine tree. Reason: possible improvements in rayon, cellophane, photographic film and paper, lacquers, plastics and many other of the 500 products made from the tree's chemical cellulose.

According to Dr. R. L. Mitchell, manager of research, Rayonier, Inc., the experiment marks the beginning of a new era in forest chemistry. Dr. Mitchell explained that the injection of the tree with radioactive substance will



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the ARI Exposition
Booth No. 258**

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and sole makers
of METALFLO
tubing

**Expect the BEST
brass and copper
products from**

Have you ever thought of using H&H Metalflo as a possible substitute for seamless brass or copper tubing? A sturdy, brazed brass tubing that costs less than seamless, Metalflo is today being used in the manufacture of numerous products such as fireplace fixtures, plumbing brass goods, spraying equipment, automotive tubular parts and many others.

H&H TUBE AND MANUFACTURING CO.

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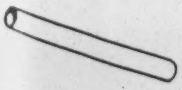
METALFLO

LOCKSEAM

COIL STRIP

SEAMLESS TUBING

TUBULAR PARTS

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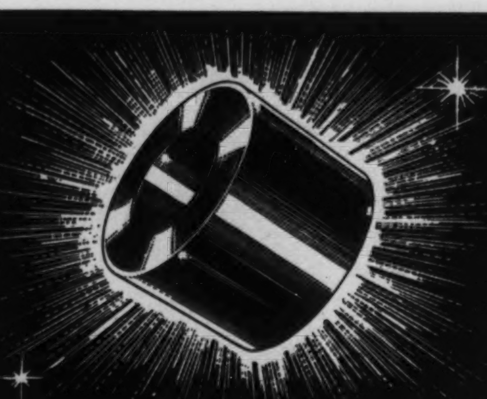

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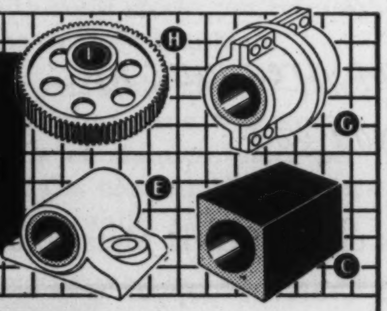
GRAPHALLOY is widely used for self-lubricating piston rings, seal rings, thrust and friction washers, pump vanes.



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GRAPHALLOY has high-performance electrical properties: *low electrical noise, low and constant contact drop, high current density, minimum wear!*

Brush Holders and Assemblies, Coin Silver Slip Rings and Assemblies available.

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tag this year's growth ring for use in later research. The tree will eventually be cut down, debarked, ground into small chips and turned into cellulose. The radioactive tracers will help researchers follow cellulose characteristics and behavior right on through to any end product capable of being reproduced in the laboratory.

Engineers

Dr. Oscar T. Marzke has rejoined U. S. Steel Corp., as vice president, fundamental research after a ten-year association with U. S. Naval Research Laboratory.

Charles A. Mueller has been named chief engineer, Gas Process Div., Lindberg Engineering Co.

John P. Day is now with Cohu Electronics, Inc. as chief development engineer of Kin Tel Div.

Dr. Alex Stewart has been elected president and general manager of R-N Corp.—a new organization owned equally by National Lead Co. and Republic Steel Corp.

Dr. J. Howard Brown is now research manager of phosphorus chemistry research at the analytical and physical chemistry laboratories, Hooker Electrochemical Co. **Morton S. Kircher** has also been made a research manager, in charge of inorganic and electrochemical research and the Virgo laboratory.

George D. Keller has been appointed chief engineer, Brooks Rotameter Co.

Stanley M. Norwood has been named assistant to the president, Electro Metallurgical Co. Mr. Norwood will continue as vice president of this Union Carbide Corp. division.

Whitney Collins is leaving Continental Aviation and Engineering Corp. to join Solar Aircraft Co. as executive assistant to the president.

Dr. John H. Hoke has moved to Crucible Steel Co. as supervisor of

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FOR CHROMATE TREATING

ZINC

#50:	Bright, clear, lustrous, nickel-like, corrosion-resistant; requires leach.
#51:	Similar to #50, but bluish chrome-like color.
#52:	Low-cost, no leach, bright, passive.

CADMIUM

#50:	See under Zinc, above.
#53:	Improved solubility, control, safety in handling; requires leach.

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Cobra:	Bright, yellowish, decorative and/or protective film, non-fuming, single dip.

ALUMINUM

222M Sealer:	Clear or colored film for corrosion protection and paint bond.

MAGNESIUM

MPD 60:	Yellowish film for corrosion protection and paint base.

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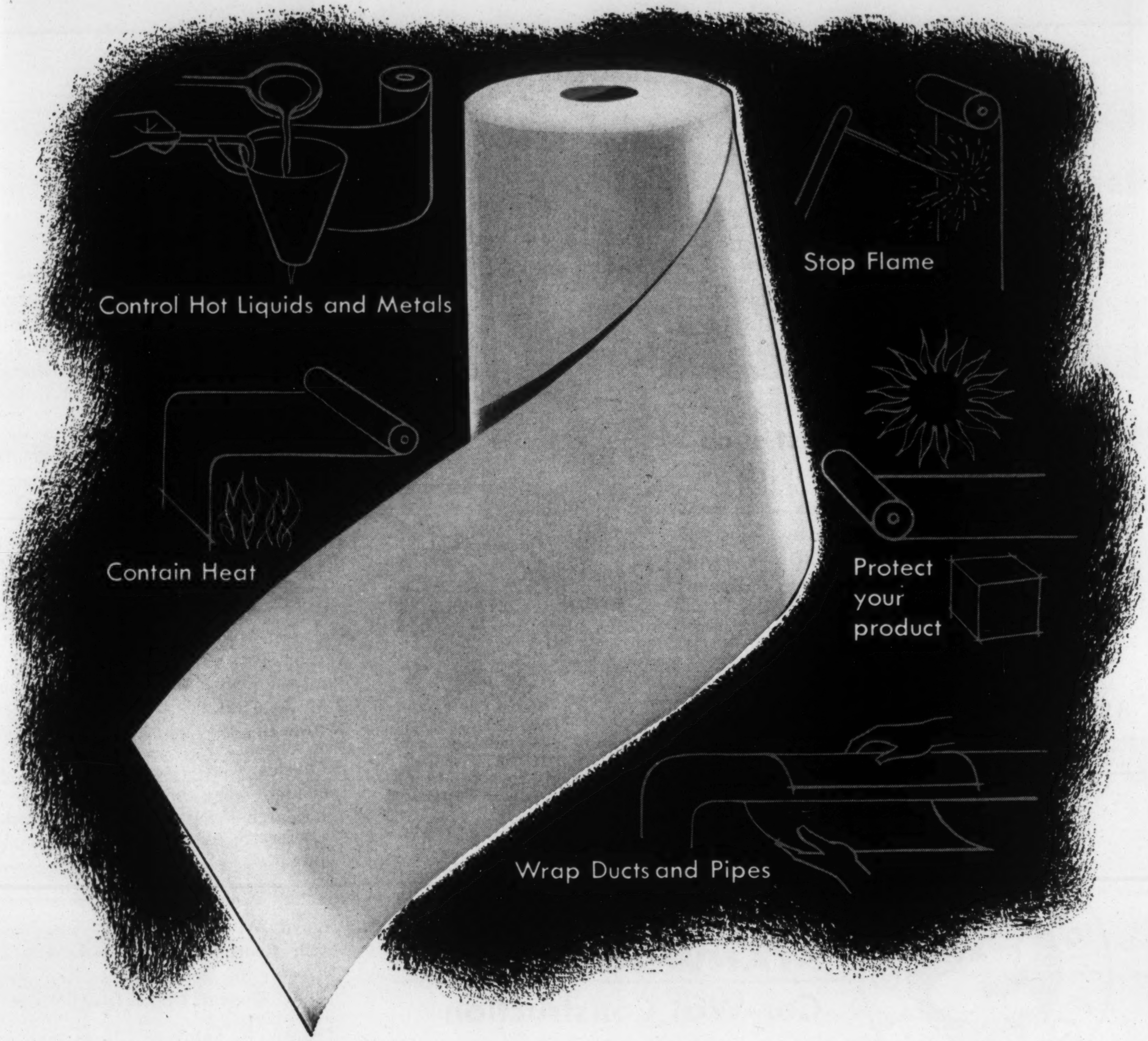


J-M ASBESTOS PAPERS—the fast, low-cost way to keep heat and flame under control

Here's the magic mineral, asbestos—in low-cost, easy-to-use form—ready to help you control heat and flame *fast* in every step of your operation.

In over 70 different industries versatile Johns-Manville Asbestos Papers are on the job—keeping heat in or out—keeping corrosion and flame under control—keeping production costs down. In sheets and tapes, these flexible papers can be applied practically anywhere. They are not affected by temperatures to 400F—keep char and smoke to a minimum.

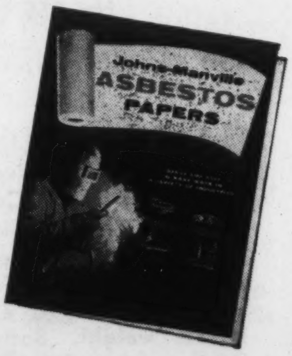
Keep costs down

Low-cost J-M Asbestos Papers pay their way over and over again, because they won't burn or deteriorate under most working conditions. You cut just the amount you need for any job—and re-use it again and again.

A grade and style for every job

The complete line of J-M Asbestos Papers includes a full range of thicknesses in widths up to 72 inches in *Commercial Paper and Rollboard* for covering ducts and pipes, for thermal insulation and gaskets—*Fibroid papers* for use as base sheets in electrical insulation, and *special papers* for electrolytic cells, sign manufacturing, welding, and many other uses.

For a Free Brochure on J-M Asbestos Papers, write Johns-Manville, Box 14, New York 16, N.Y. In Canada, Port Credit, Ont.



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Use both Knoop and 136°
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The new
STANWOOD
Cor-Wal Construction
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No. 355

Following exhaustive tests, Stanwood offers the new Cor-Wal construction Stacking Baskets. Sides of this heat resistant alloy basket are corrugated rolled metal, imparting a longer service life, greater load carrying ability and lighter weight. Bottom grid, grid supporting base ring and stacking ring at top are high temperature cast alloy. Use Stanwood's broad experience and modern facilities for your heat treating equipment—baskets, trays, fixtures, retorts, pots, carburizing boxes and furnace parts. Send for catalog. Stanwood Corporation, 4813 West Cortland Street, Chicago, 39, Illinois.

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the Stainless Steels Section of the Central Research Laboratory.

Basil T. Lanphier and **Howard O. Beaver** have accepted new positions with Carpenter Steel Co. Lanphier has been promoted to manager of research and Beaver to production metallurgist in charge of melting and hot working.

Edgar W. Engle has been appointed development engineer by Kennametal, Inc.

R. R. Furney, M. M. Schall, R. E. Fletcher and **Carl Gustafson** have been named assistant chief engineers at Dana Corp. Mr. Furney was assigned to the Clutch Div., Mr. Schall to the Hydraulic Transmission Div., and Mr. Fletcher and Mr. Gustafson to the Mechanical Transmission Div.

Charles W. Ostrander has been appointed technical director of Allied Research Products, Inc. **Raymond Stricklen** has been named laboratory director at Allied's Development Laboratory.

Lloyd W. Root is now associated with George Behm & Sons Co. as director of research for the Precision Optical Glass Div.

Francis B. Foley has been engaged by Pencoyd Steel & Forge Corp. as executive metallurgical engineer.

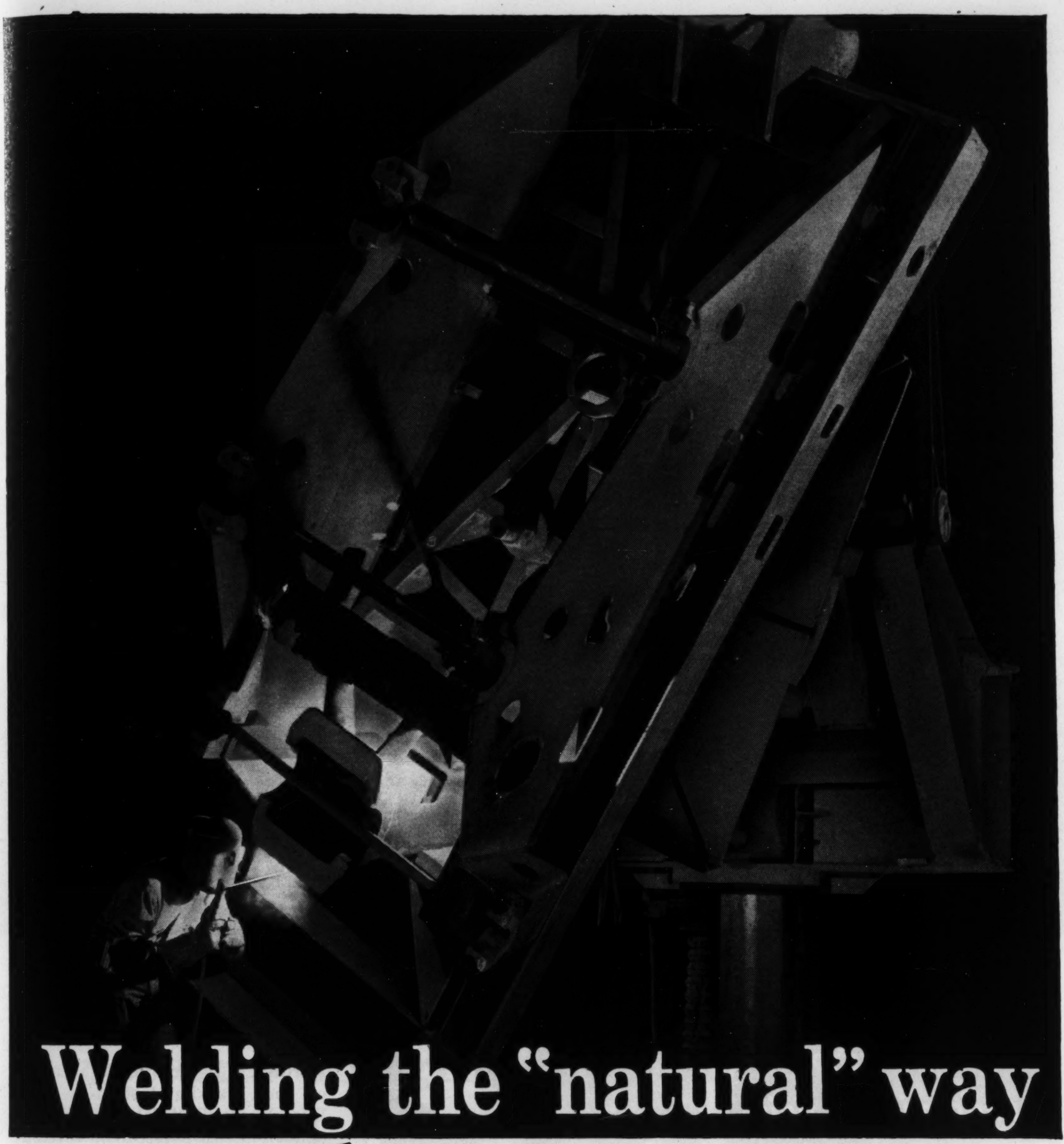
R. J. Keller, A. C. Smith Corp., is now chief engineer of the Welding Products Div.

Companies

Bendix Aviation Corp. will double manufacturing facilities of its Computer Div.

DeVilbiss Co. has agreed to purchase the **Newcomb-Detroit** Co. through an exchange of stock. Newcomb-Detroit will be operated as a DeVilbiss subsidiary.

Electro Metallurgical Co., a division of Union Carbide Corp., is constructing an addition to its process research building in Niagara Falls, N. Y. Scheduled for completion in November, the addition will more



Welding the "natural" way with P&H welding positioners

Downhand welding is faster, easier, more economical. And P&H Welding Positioners enable your weldors to quickly and easily position their work for faster welding in the downhand — the *natural* — position.

Downhand welding also permits the use of hotter, faster electrodes. Penetration is much better, welds are smoother, neater, more uniform.

By simply pressing control buttons, the weldor safely positions pieces as heavy as 100,000 pounds for maximum comfort and speed of welding. Worker efficiency goes up — and so does your production!

What's more, labor and overhead — the vital factors that cost you 86¢ out of every welding dollar — can be cut in half by using P&H Positioners for weldment handling.

Investigate P&H Welding Positioners. Write to Dept. 320G, Harnischfeger Corp., Milwaukee 46, Wisconsin.

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How Industry Uses INVESTMENT CASTING to cut production costs!

WAS 6 PARTS

An intricate collar, used in sonar equipment, originally machined in 6 parts from bar stock, required blanking, forming, pre-machining and welding. Operations that created many problems and proved too expensive.

NOW 2 PARTS

Investment Casting produced the same collar in 2 parts. It eliminated all blanking, forming, pre-machining and welding. It simplified final assembly. And it *materially* reduced the cost of production.*

*Details on request

Send today for our new 12-page booklet, "Modern Precision Investment Casting." It tells you the "how and why" of Investment Casting.

If you have a precision parts problem, perhaps Investment Casting can help you. If the part measures 6" x 5" or smaller, if it weighs 3 lbs. or less, if it requires starting tolerances as close as plus or minus .005" per linear inch, if it now needs 5 or more fabrication steps, *maybe you NEED Investment Casting.*

ALEXANDER SAUNDERS & CO.
Precision Casting Equipment and Supplies
93 Bedford Street, New York 14, N. Y.
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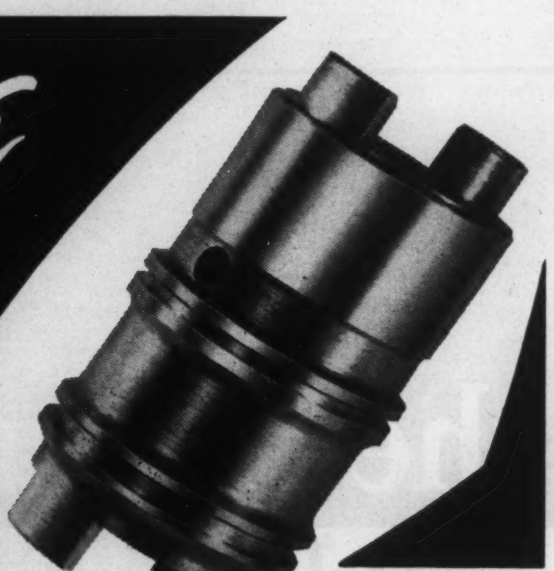
Photo and data courtesy of The International Nickel Co., Inc.



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- high production
- uniformity of finish

Savings on deburring, descaling, grinding, polishing, coloring and surface improvement by Roto-Finish barrel finishing processes are tremendous. Expensive hand finishing can be eliminated.

Results Guaranteed! Send samples of finished and unfinished parts to Roto-Finish. Roto-Finish Sample Processing Laboratories will prove to you — before you buy — that Roto-Finishing will give you the results you want. Furthermore, Roto-Finish guarantees to produce the same results in your plant that are achieved in sample processing.

Let Us Help You with Your Problems

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Phone FI 3-5578
3726 Milham Rd., Kalamazoo, Mich.

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News OF INDUSTRY

than double space now available for chemical metallurgy research.

Apex Smelting Co. has acquired full ownership of **National Metallurgical Corp.**

Escambia Chemical Corp. is constructing a 50,000-sq-ft research center at Wilton, Conn., for occupation early in 1958.

Columbia-Southern Chemical Corp., a subsidiary of Pittsburgh Plate Glass Co., has acquired half interest in **NRC Metals Corp.**, a National Research Corp. subsidiary. NRC Metals will be known as **Columbia-National Corp.** and will be operated as a jointly owned subsidiary of the parent companies.

Westinghouse Electric Corp. is constructing a new manufacturing and repair facility at Compton, Calif. Scheduled for completion by November, the building will provide 88,000-sq-ft of plant and office space.

Era Engineering, Inc., Santa Monica, Calif., is a newly formed corporation. Its objective is the development of new systems and devices in the electronics, radiation and rocketry fields.

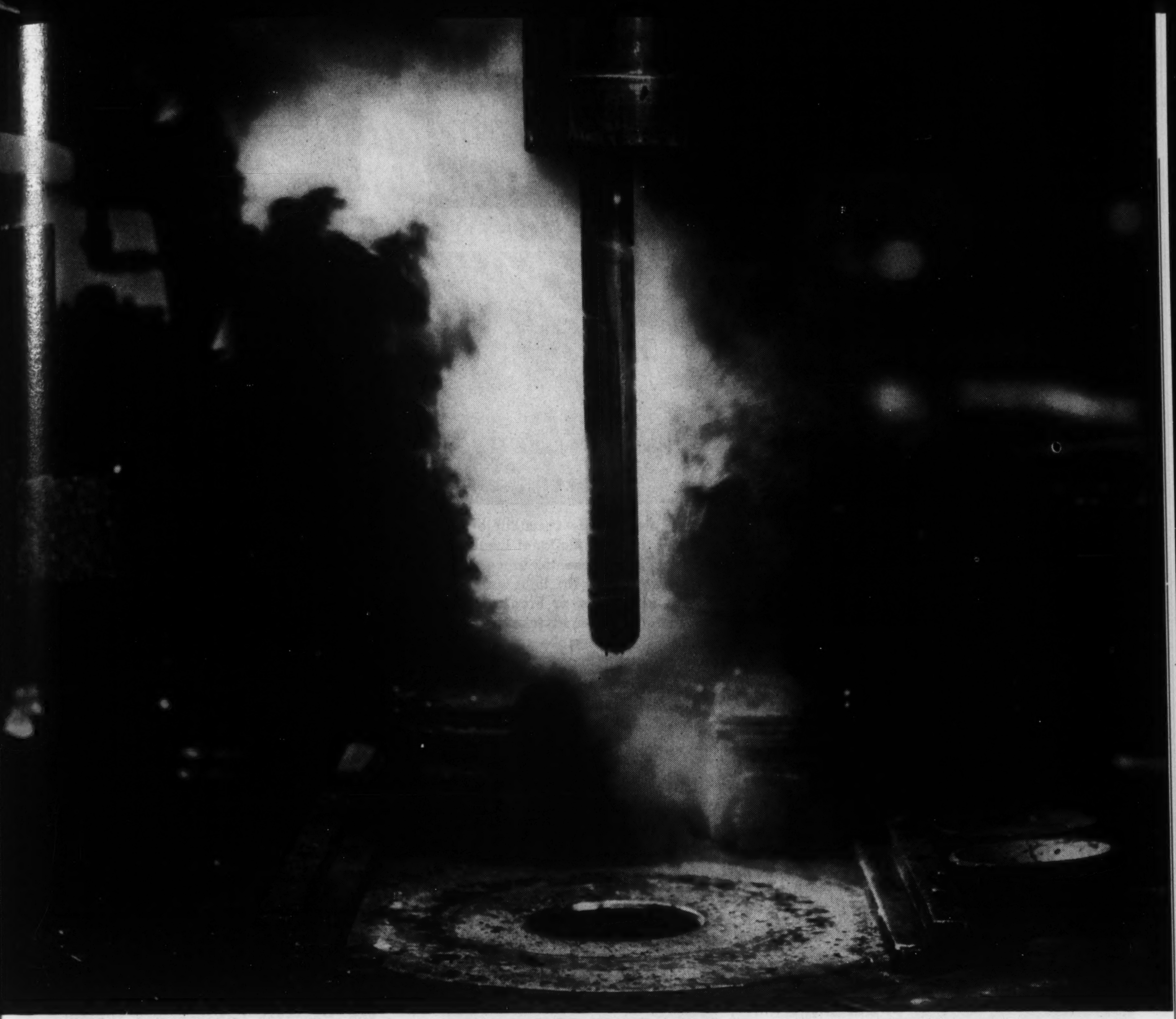
General Ceramics Corp. is constructing a new building in New Jersey to provide additional production facilities.

Martin Co. is this year's recipient of the Franklin Institute's John Price Wetherill Medal for "recognition of intensive research, development and manufacture of bonded structures." The medal is being presented to a company, rather than an individual, for the first time in almost a quarter century.

Acme Steel Co. has started construction of a $23 million steelmaking plant expected to be in operation early in 1959. It will be the first U. S. plant to use a new steel production process—the combination of hot blast cupolas and oxygen blown converters—and will have an initial capacity of 450,000 ingot tons a year.

American-Marietta Co. and **Booty Resineers, Inc.** have joined forces

For more information, circle No. 41



Tough 2½" diameter mandrel at Rc 44 on 1150 ton brass extrusion press. Scovill Manufacturing Co.

Mandrel of HALCOMB 218 retains toughness and hardness at hot work temperatures...

This mandrel is made of Halcomb 218—a tough, air-hardening hot work steel. Halcomb 218 is suitable for tools like this which require a higher degree of toughness at moderately elevated temperatures than is obtainable with the tungsten types of hot work steels. And Halcomb 218 *retains both* its hardness and strength at these temperatures.

For example, at a hardness of Rc 44, Halcomb 218's Charpy Impact Strength is 33 ft-lbs at 500F. And it will retain this hardness after 1 hour, after 10 hours and even after 100 hours at temperatures up to 900F.

Properties like these cut tooling costs. The mandrel shown above is good for 1200 pushes, for example, and even then all it needs, usually, is repolishing before being used again.

Halcomb 218 is particularly useful for all hot work operations on which drastic coolants are used. It even resists breaking very successfully when water cooled in operation. If these sound like advantages you can use, call your local Crucible representative for more complete data. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America

Canadian Distributor—Railway & Power Engineering Corp., Ltd.

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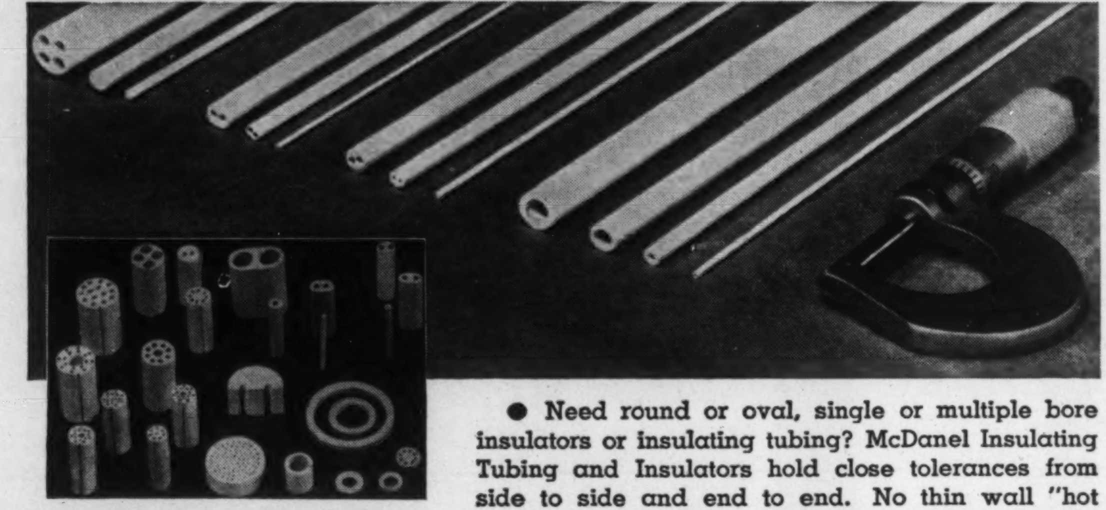
McDANEL

INSULATORS AND INSULATING TUBING



McDanel round or oval Insulators, 1", 2" or 3" lengths. Flexible and adaptable to irregular thermocouple connections. Special sizes and lengths available. Guaranteed up to 2900° F.

● Need round or oval, single or multiple bore insulators or insulating tubing? McDanel Insulating Tubing and Insulators hold close tolerances from side to side and end to end. No thin wall "hot spots" allow heat to deteriorate or break thermocouple wires. McDanel Tubing and Insulators are guaranteed up to 2900° F. We make special sizes and lengths up to 80 holes. Contact us today!

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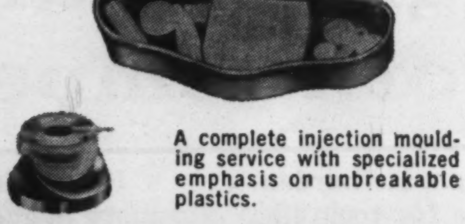
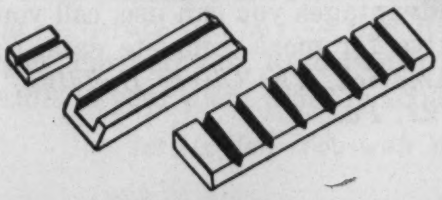
The plastic mouldings that simulate brass, chrome or copper. Use it on any raw edge for a sparkling finish. It's highly flexible. Dimensionally stable, resists heat, salt water and corrosive elements. Never tarnishes.

Custom Moulding



A complete injection moulding service with specialized emphasis on unbreakable plastics.

Magnets



We are specialists in small, custom-cast Alnico III Type magnets.

Mirrors

A complete bent glass and silvering service. We manufacture parabolic, spherical, elliptical, magnifying and minifying mirrors.

Write for specification catalogs.

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through an exchange of stock. Booty will continue present operations as a division of American-Marietta.

Spencer Chemical Co. has started production at its new nylon plant in Henderson, Ky. A feature of the new plant is a pilot size production unit for nylon resin research.

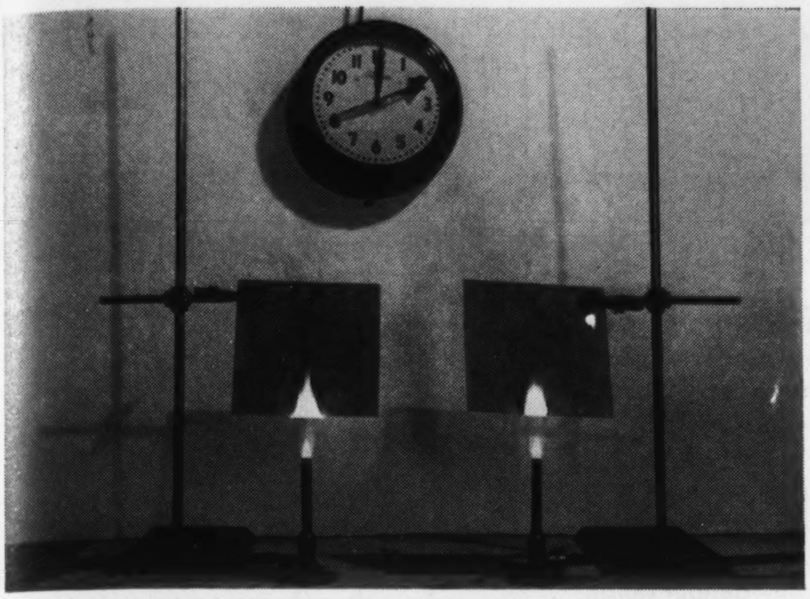
Societies

American Society of Tool Engineers announces that its local seminars were so successful that a new series of Tool Engineering Seminars will be given this winter on a nation-wide basis.

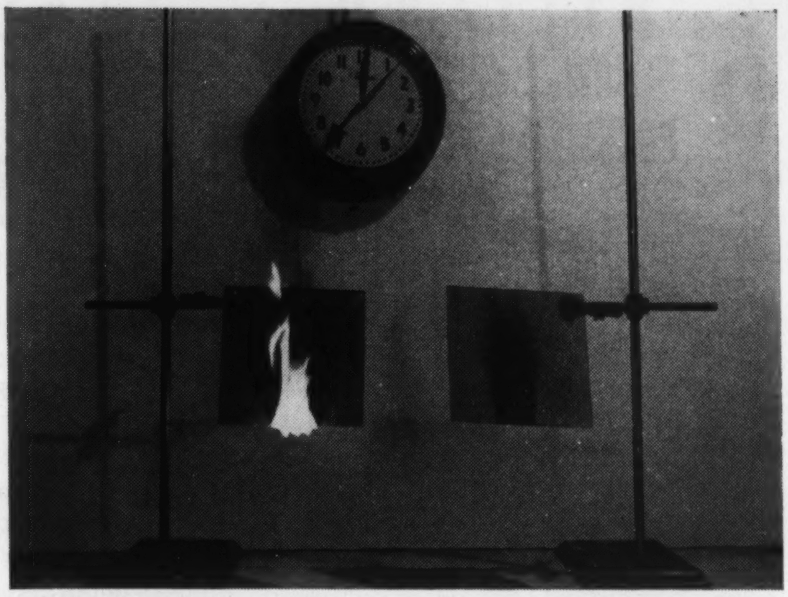
American Society for Testing Materials has elected the following officers: president—R. T. Kropf, Belding Heminway Co.; vice president—F. L. LaQue, Development and Research Div., International Nickel Co. Directors elected for three-year terms are: C. L. Clark, Timken Roller Bearing Co.; A. E. Juve, Technical Services Research, B. F. Goodrich Co.; J. H. Koenig, School of Ceramics, Rutgers University; R. E. Peterson, Research Laboratories, Westinghouse Electric Corp.; and R. W. Seniff, Baltimore & Ohio Railroad Co.

Recipients of awards are: R. U. Blaser & J. J. Owens—the Charles B. Dudley Medal; Walter Ramberg and L. K. Irwin—the Richard L. Templin Award; K. G. Compton and A. Mendizza—the Sam Tour Award; Stanton Walker—the Frank E. Richart Award; R. C. Adams—the Max Hecht Award; and T. C. Powers—the Sanford E. Thompson Award. Awards of Merit for outstanding service were presented to: John W. Bolton, Donald L. Colwell, A. G. H. Dietz, Theodore Parker Dresser, Jr., Paul V. Faragher, Edgar W. Fasig, William A. Kennedy, Wilmer H. Koch, R. Earl Penrod, Frank W. Reinhart, Francis G. Tatnall and Walter C. Voss.

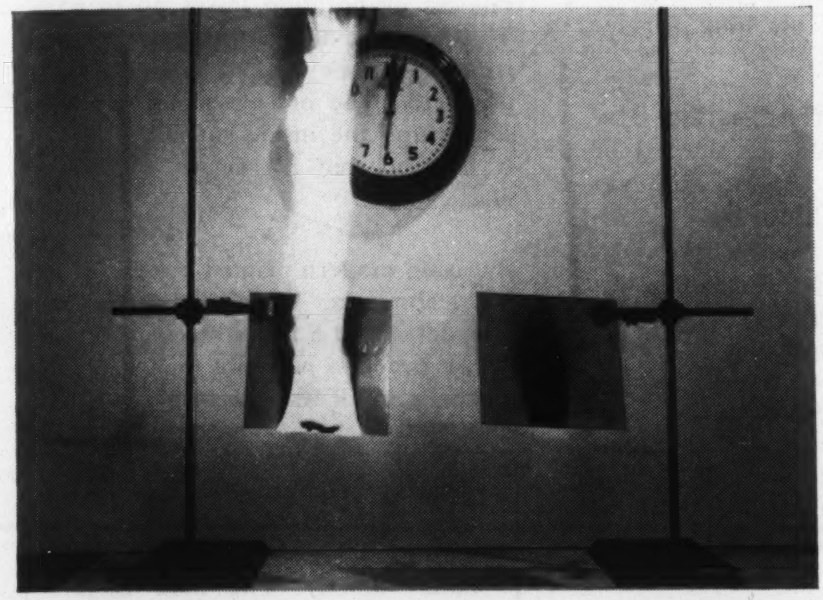
American Society of Mechanical Engineers has elected four Fellows. They are: Ray N. Benjamin, Georgia Power Co.; Carey H. Brown, formerly of Eastman Kodak Co.; George M. Muschamp, Minneapolis-



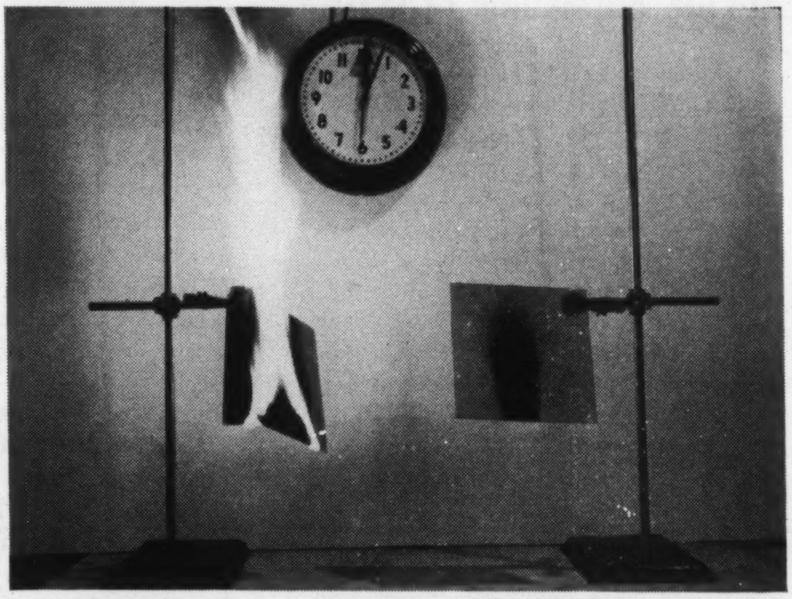
10 SECONDS Flame test contrasts epoxy laminates cured with conventional hardener (left) and with HET anhydride (right).



36 SECONDS Flame sources removed at 30 seconds. HET-cured laminate snuffs out instantly with local charring only.



2 MINUTES Conventional laminate continues to burn freely.



3 MINUTES Conventional laminate is almost totally destroyed.

Where can you use an epoxy that resists flame?

Your laminates and castings shrug off heat, moisture—even fire—when you cure with HET® anhydride

What could you do with
- —a glass-reinforced epoxy laminate that keeps practically all its flexural strength *even when you heat it within the* 300-350°F range?
- —an epoxy potting resin that retains its room-temperature electrical properties *at high humidities and at temperatures above 300°F*—and won't feed a fire?

These examples only hint at the amazing performance you can get when you use HET anhydride as a curing agent for your epoxy resins.

Conventional curing agents can't give you HET's combination of strength at high temperatures; fire resistance; high heat distortion temperature; good power factor and stable dielectric constant, both unaffected by moisture.

For easier casting or wet layup, you need not handle HET anhydride hot. You can mix it with another anhydride to form a curing system that *stays liquid at room temperature.* Also, HET anhydride has very low toxicity.

For complete information on HET anhydride, methods of use, and properties of cured resins, write on your business letterhead for Bulletins 19 and 43.

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Assembly-line application of NOPCO® LOCKFOAM PLASTICS

... with NOPCOMETER®, the proven automatic metering, mixing and dispensing machine. Nopco LOCKFOAM, the versatile urethane foam plastic which when poured in place shapes itself to fill any cavity regardless of configuration, can now be incorporated into a variety of products on an economical production line basis with the Nopcometer.

The Nopcometer is the answer to the need for accurate, dependable metering, mixing and dispensing of any of the Lockfoam formulations at the production line *automatically . . . and intermittently*. Compact portable design permits easy transfer to any point along the assembly line for manufacture of both small and large units. The illustration above shows the Nopcometer in operation pouring Lockfoam P502 structural panels 2" x 4' x 8' at a rate of 20 lbs. min. An increase of 2400% over patch pouring.

Structural and insulating sandwich panels, trailer truck bodies, freezer cabinets, and encapsulated electronic assemblies are just a few of the products now being produced daily with current Lockfoam formulations.

Lockfoams are formulated to provide any degree of rigidity or flexibility, tensile strength, density, and thermal or electrical properties. And with the Nopcometer manufacturers now have a combination that opens unlimited possibilities for new manufacturing techniques . . . new product designs . . . and vastly better product performance. Both are now available for large scale volume production requirements. We await your inquiry.

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News OF INDUSTRY

Honeywell Regulator Co.; and Thomas F. Perkinson, General Electric Co. ASME Fellows are limited to engineers "of acknowledged attainment with 25 years of active practice in the profession and who have been Society members for 13 years." ASME is also bestowing its highest honor, honorary membership, on E. G. Bailey, former president. Mr. Bailey is cited for his imaginative leadership, his inspired guidance for youth and his long service to the Society.

American Society for Testing Materials has presented its Award of Merit to John W. Bolton (in absentia) in recognition of distinguished service to the Society. Mr. Bolton, retired, was formerly director of metallurgical research and testing, Lunkenheimer Co.

Society of Vacuum Coaters has been chosen as the name of a new group tentatively listed in our May 1957 issue as the Vacuum Metallizing Assn. M. S. Adler, 2036 E. 22nd St., Cleveland 15, may be contacted for further information.

Environmental Equipment Institute has elected the following officers: president—E. S. Brown, Standard Cabinet Co.; executive vice president—R. J. Jacobson, Cincinnati Sub-Zero Products; and general manager—Dr. George D. Wilkinson, George D. Wilkinson Co. Executive committee members are: Jack Shamroth, American Research Corp.; Alexander I. Newman, Hudson Bay Div., Labline, Inc.; and Robert Brown, Tenney Engineering, Inc.

Institute of Environmental Engineers has elected the following officers: president—Henry F. Sander, Vapor Heating Corp.; executive vice president—Roger J. Amorosi, Parameters, Inc.; vice president, fiscal affairs—Harold C. Jones, Westinghouse Air Arm Div.; vice president, membership—Irving P. Polak, MJL Operations, Marquardt Aircraft Co.; vice president, publications—Cyril C. Campbell, Convair Astronautics; and vice president, local chapters—Arthur Billet, Aero Hydraulics Div., Vickers, Inc.

(News of Meetings on p 274)

STRAITS TIN REPORT

MALAYAN TIN BUREAU

New developments in the production, marketing and uses of tin

A tin "doughnut" is now being used to reduce water evaporation from reservoirs—an important conservation measure in our chronic, and growing, shortage of water. It dispenses flakes of hexadecanol, which lab studies indicate reduces evaporation losses up to 65%. This "doughnut" is a tub-shaped device without top or bottom, and 6 feet in perimeter. The outside surface is brass screen and the inside surface sheet tin. It is supported by means of inflated plastic bags.

★ ★ ★

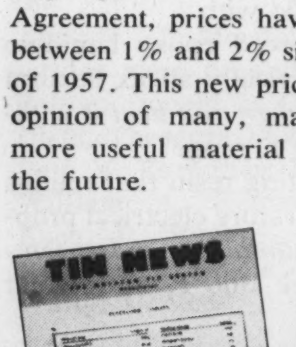
By using modern printed circuit soldering techniques, British scientists have now developed a radar receiver so compact it occupies no more than 170 cubic inches, a small fraction of a cubic foot.

Development of a new tin field near Kampar, Perak, in the Federation of Malaya, may be undertaken shortly. The field is reported to contain millions of dollars' worth of tin ore.

Add one more "product" to the growing list now supplied in tin cans. This time it's fresh Florida air, packed as a souvenir by a novelty company in the Sunshine State.

★ ★ ★

The International Tin Council recently estimated that the surplus of tin from world production this year will be between 5000-7000 long tons. Thanks in large part to the International Tin Agreement, prices have fluctuated only between 1% and 2% since the beginning of 1957. This new price stability, in the opinion of many, makes tin an even more useful material in any plans for the future.



Ask us to send you TIN NEWS, a monthly letter. It will keep you posted on tin supply, prices, new uses and applications.

The Malayan Tin Bureau
Dept. 24L, 1028 Connecticut Ave., Washington 6, D.C.

For more information, circle No. 402

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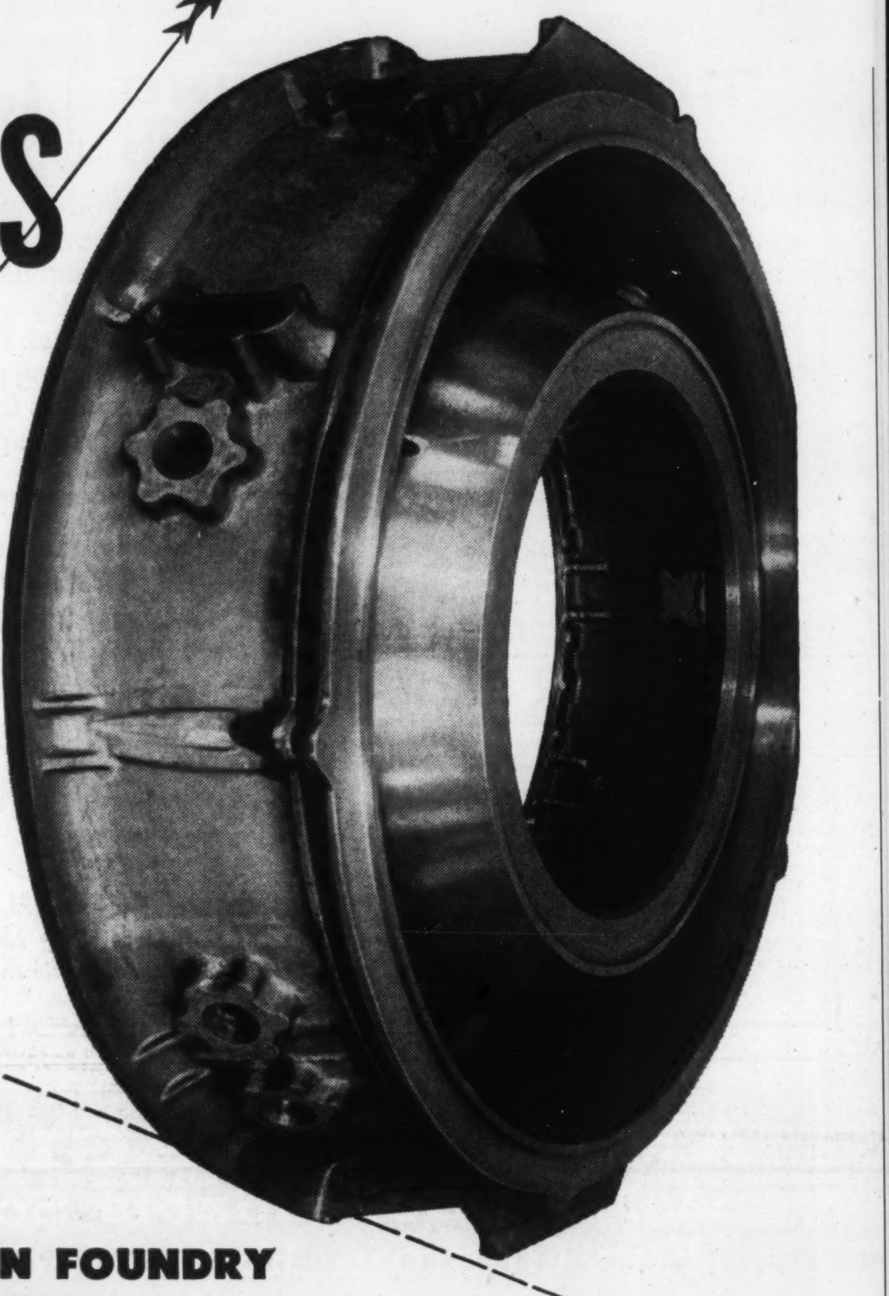
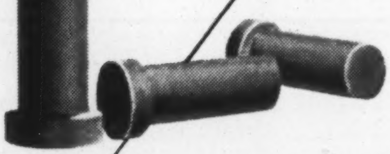
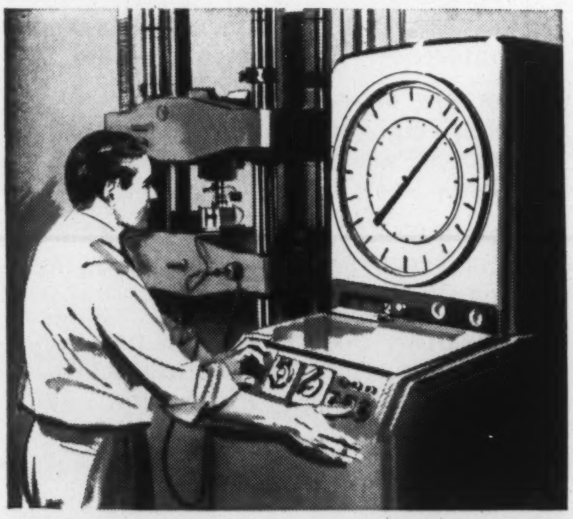




METALS PROCESSING DIVISION FOUNDRY handles wide range of sizes, closely controls dimensions



Precision testing methods provide close control of casting quality

Curtiss-Wright's Metals Processing Division today offers your industry precision castings of critical parts in a wide variety of sizes, and with closely controlled dimensions. For example, in the large casting shown, tolerance is ±.030 over 36″ diameter. From its modern, completely equipped foundry in Buffalo, the Division supplies heat, corrosion and abrasion resistant castings from a full range of special-property alloys, including ductile iron... by sand, centrifugal, ceramic or shell processes.

Precision alloying techniques, modern melting controls with spectrometer testing, X-ray control by experienced radiographers – all add up to castings with superior physical and mechanical properties . . . mean better and more dependable products for the critical needs of industry. Qualified design engineering assistance is a part of the comprehensive Metals Processing Division service. Write for details.

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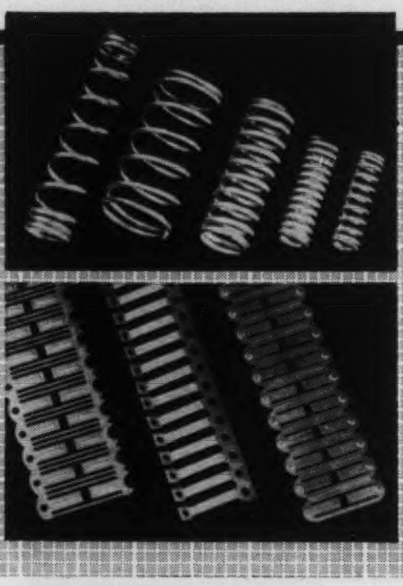

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For more information, turn to Reader Service card, circle No. 571

News OF INDUSTRY

Meetings

SOCIETY OF PLASTICS ENGINEERS, regional technical conference, Southern California section. Los Angeles. Nov 11.

STEEL FOUNDERS' SOCIETY OF AMERICA, technical and operating conference. Cleveland. Nov 11-13.

NATIONAL PAINT, VARNISH AND LACQUER ASSN., annual convention. Los Angeles. Nov 12-14.

AMERICAN STANDARDS ASSN., eighth national conference on standards and 39th annual meeting. San Francisco. Nov 13-15.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, in cooperation with American Physical Society, American Institute of Mining, Metallurgical and Petroleum Engineers, Institute of Radio Engineers and Office of Naval Research, conference on magnetism and magnetic materials. Washington, D. C. Nov 18-21.

INVESTMENT CASTING INSTITUTE. Chicago. Nov 19-21.

COMMERCIAL CHEMICAL ASSN. AND CHEMICAL MARKET RESEARCH ASSN., annual meeting. Houston, Tex. Nov 20-21.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS, annual meeting. New York. Dec 1-6.

SOCIETY FOR APPLIED SPECTROSCOPY. New York. Dec 3.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, 15th annual electric furnace conference. Pittsburgh. Dec 4-6.

SOCIETY OF THE PLASTICS INDUSTRY, INC., eighth Film, Sheeting and Coated Fabrics Div. conference. New York. Dec 10-11.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS, winter general meeting. New York. Jan 20-24.

AMERICAN SOCIETY OF HEATING AND AIR CONDITIONING ENGINEERS, 64th annual meeting. Pittsburgh. Jan 27-29.

SOCIETY OF PLASTICS ENGINEERS, 14th annual national technical conference. Detroit. Jan 28-31.

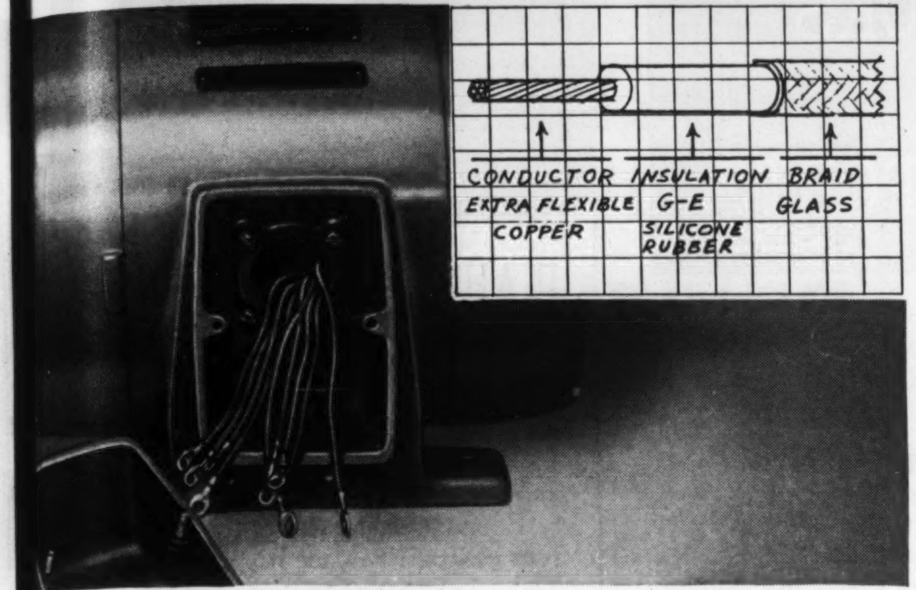
AMERICAN SOCIETY FOR TESTING MATERIALS, committee week. St. Louis. Feb 9-15.

AMERICAN INSTITUTE OF MINING, METALLURGICAL AND PETROLEUM ENGINEERS, annual meeting. New York. Feb 16-20.

For more information, circle No. 549 ➤

HOW TO SOLVE PRODUCT DESIGN PROBLEMS WITH SILICONE IDEAS

APPARATUS LEAD WIRE

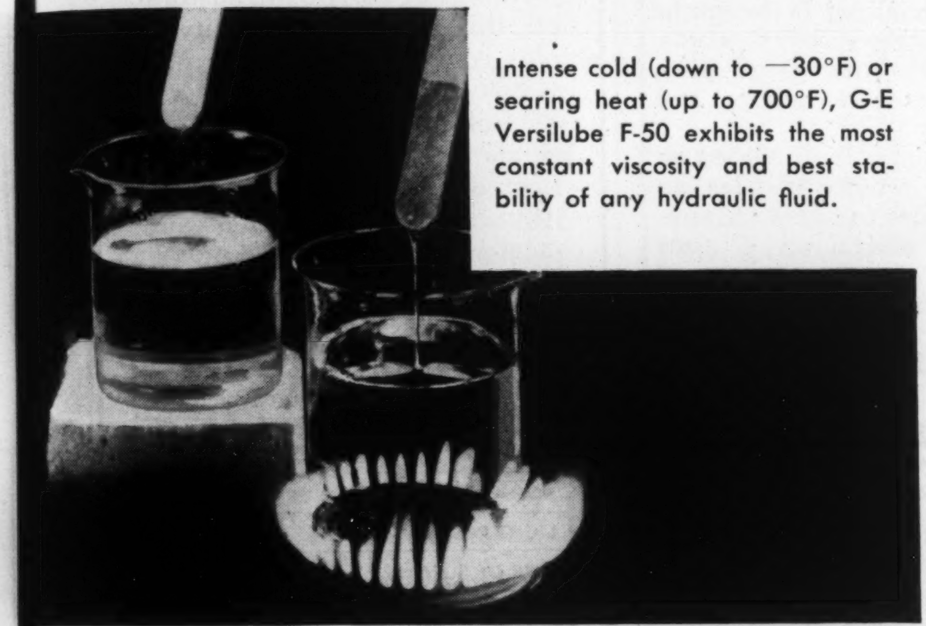


Problem: *Eliminate a potential failure point, upgrade Class B equipment for temporary overloads.*

Solution: Lead wire insulated with G-E silicone rubber.

Silicone insulation, the standard for Class H equipment, enables manufacturers to make smaller, more compact motors, generators, and transformers. Class B equipment can also be upgraded to provide a safety margin for intermittent high temperature operation through the use of silicones. For example, silicone insulated lead wire eliminates a major source of failure in Class B motors, lets you standardize on one type of lead wire for both Class B and H equipment. Motor and apparatus lead wire made with G-E silicone rubber withstands moisture and has ozone resistance approaching that of mica. It is easy to strip and solder and is flexible at low temperatures.

HYDRAULIC FLUID



Intense cold (down to —30°F) or searing heat (up to 700°F), G-E Versilube F-50 exhibits the most constant viscosity and best stability of any hydraulic fluid.

Problem: *Find a hydraulic fluid that functions over the —30°F to 700°F range.*

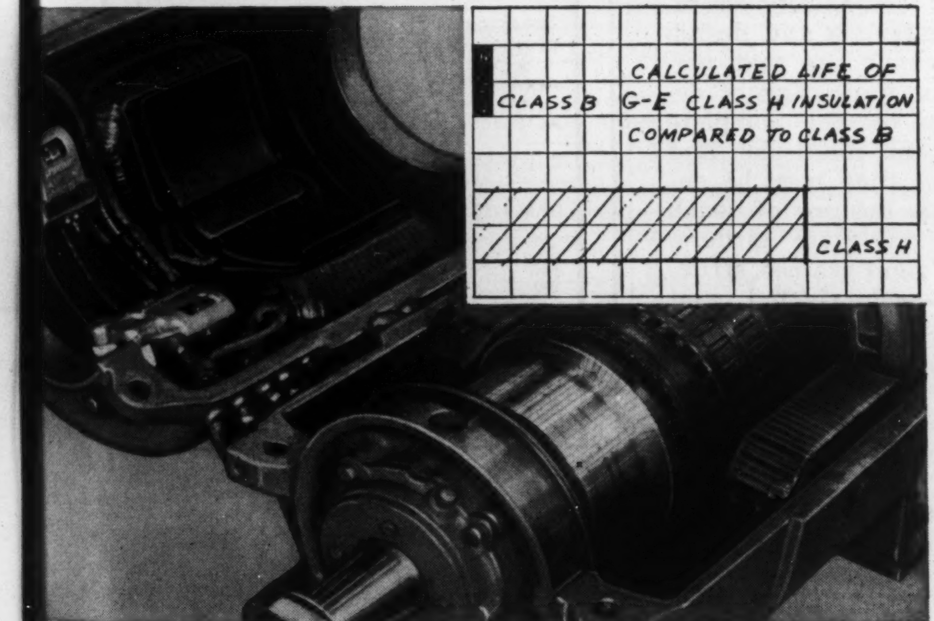
Solution: *Versilube F-50*, General Electric's new silicone fluid, with the best performance over this range of any hydraulic fluid now available.

Over the —30°F to 700°F range, *only* General Electric's new silicone fluid, Versilube F-50, provides adequate performance in all these areas: thermal stability, lubricity, viscosity-temperature coefficient, oxidative stability, oxidation threshold temperature and hydrolytic stability.

No other serviceable hydraulic fluid matches the thermal stability of G-E Versilube F-50—up to 600°F and for many applications, up to 700°F. Its lubricity is unequalled at temperatures as high as 700°F and comparable to other hydraulic fluids in the moderate ranges. Versilube F-50 also maintains a more nearly constant viscosity than other hydraulic fluids over the —30°F to 700°F range.

For more information about Versilube F-50 and other G-E silicone fluids, send the coupon below.

CLASS H DC MOTORS


CALCULATED LIFE OF G-E CLASS H INSULATION COMPARED TO CLASS B
CLASS B
CLASS H

Problem: *Design a coil for DC motors that will eliminate insulation failure and increase normal operating life at least 10 times.*

Solution: Combine inorganic materials with G-E silicones in an improved insulation system.

Auxiliary mill motors often meet unexpected high ambient temperatures, unforeseen extra long duty or other emergency conditions—any of which can cause "roast-outs." This problem has been solved by a Class H G-E silicone insulation system which will withstand continuous high temperatures. Silicone-treated mica mat is used on commutating, exciting field and armature coils. In laboratory tests, this insulation has maintained full dielectric strength after 3½ months at 300°C.

Service life of this insulation has been calculated to be 32 times that of conventional Class B insulation. Actual tests with Class H and B motors coupled together prove that insulation with G-E silicones lasts more than 5 times as long. Five Class B motors have consecutively burned out; the Class H is still going strong.

Mail this coupon for more information:

NERAL ELECTRIC

Silicone Products Department, Waterford, New York

Section D2B9, Silicone Products Dept.
General Electric Company, Waterford, N. Y.
Please send me more information on
☐ silicone rubber for wire and cable insulation, including list of suppliers
☐ Class H insulation
☐ silicone fluids for mechanical applications
☐ I also want data on: ______

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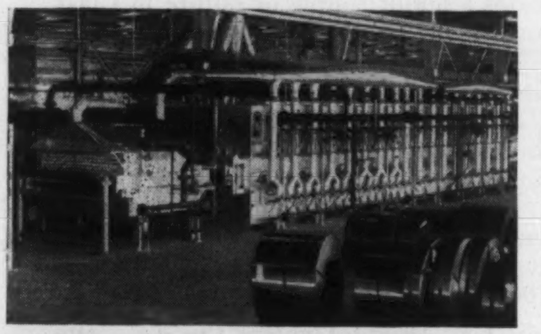
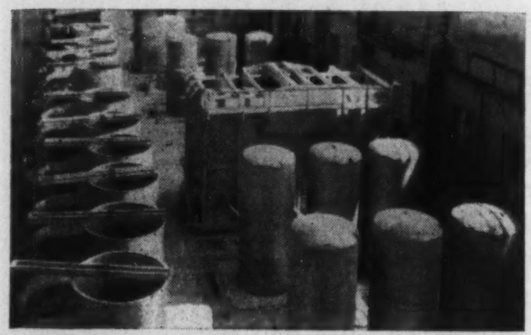


STRIP This EF gas fired unit bright anneals strip in single or multiple strands.

TUBING Tubing, strip, rod and wire in coils, strands or on reels are uniformly processed in EF furnaces.



WIRE We build single or multi-stack round, square or rectangular; fuel fired or electric bells for wire, strip, rod or other products.

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BOOKS & REPORTS

Books

Fasteners Handbook. *Julius Soled. Reinhold Publishing Corp., New York, 1957. Cloth, 6 by 9 in., 437 pp. Price $12.50.*

This unique book gives dimensional data, features and uses of such standard and specialized fasteners as rivets, inserts, screws, bolts, studs, nuts, washers, retaining rings, pins, nails, quick release fasteners and hose clamps.

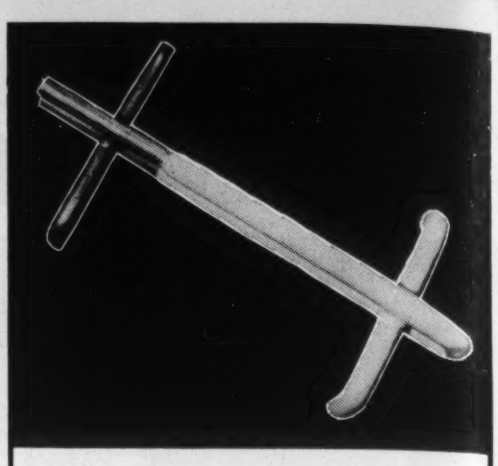
Each type fastener is discussed on a separate page which includes an illustration of the fastener, manufacturer's name and address, sizes available, and information on type of material used in making the fastener. A directory of fastener manufacturers is included.

Structural Design in Metals: 2nd Edition. *Clifford D. Williams and Ernest C. Harris. Ronald Press Co., New York, 1957. Cloth, 6 by 9 in., 663 pp. Price $8.*

Intended as a first course in the design of metal structures at the junior-senior college level, this book has been revised extensively to incorporate new materials and design methods. Throughout the text emphasis is placed on the design of details rather than on the complete structure. A general discussion and a list of problems that may be encountered in the design of such metal structures as plate girders, trusses, bearings, rigid frames, structural members, and riveted and bolted connections are given. Other chapters contain information on welding processes, rivets, bolts and pins.

The Demand and Supply of Scientific Personnel. *David M. Blank and George J. Stigler. National Bureau of Economic Research Inc., New York 16, 1957. Cloth, 6 by 9 in., 220 pp. Price $4.*

Just how serious is the scarcity of engineers in this country? The authors of this book, Drs. Blank and Stigler, say ". . . earnings of engineers up to 1955 at least, relative to the entire working population and to the professions as a separate



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Because REYNOSOL guarantees easy air release high gloss, and—important to you—*quick fusion.* For REYNOSOL customers, this means high quality . . . *plus* economies that have previously been impossible.

Look at these general specifications—and write today for complete information on REYNOSOL rack coatings and primers:

COLOR	Unlimited
WEIGHT	Sp. gr. = 1.20 or 10 lb. per gal.
TOXICITY	Can be formulated to be non-toxic
AGING PROPERTIES	Good
LIGHT RESISTANCE	Good
TYPE OF SURFACE	Dry and glossy
TENSILE STRENGTH	Very Good
SCUFF RESISTANCE	Very Good
ABRASION RESISTANCE	Very Good
ALKALI RESISTANCE	Very Good
ACID RESISTANCE	Very Good
OIL RESISTANCE	Very Good
HARDNESS	As high as 80 (Shore-A)
% FILM FORMING	100%
VISCOSITY	3,000 to 4,000 cps.
COST PER 0.001" THICKNESS	App. $.37 sq. yd.
FIRE HAZARD	None

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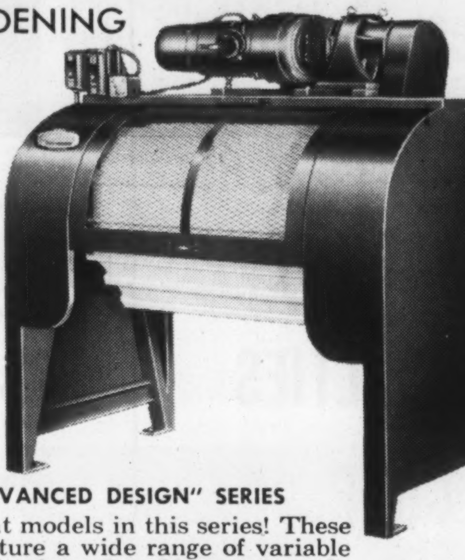
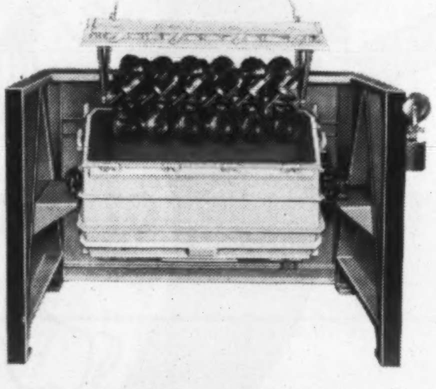
ALMCO
has the right barrel finishing equipment for you!



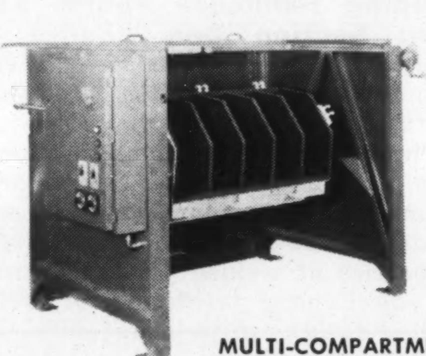
ALMCO'S "ADVANCED DESIGN" SERIES

Thirteen great models in this series! These machines feature a wide range of variable speeds (infinite from 6 to 30 r.p.m.), making possible economical deburring and finishing of the greatest variety of parts. Each unit has Almco's exclusive design features and rugged construction to stand up under all types of punishing applications.



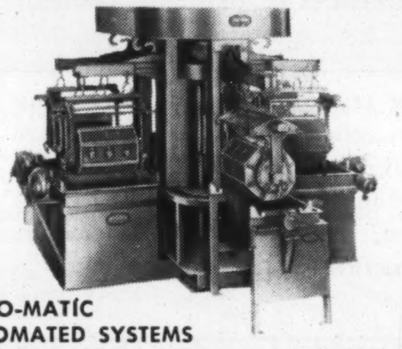
"FIXTURE" TYPE BARRELS

Pioneered by Almco for processing large and intricate parts. Custom designed fixtures hold parts securely, prevent part-on-part impingement and allow abrasive action to reach all surfaces, cavities, slots, etc. Barrels have automatic forward and reverse controls. Almco also offers integrated materials handling systems for further barrel finishing economies.



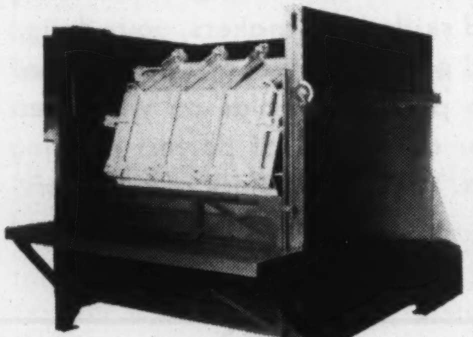
MULTI-COMPARTMENT BARRELS

Do you have these deburring and finishing problems — wide variety of parts or small quantity runs where fixtures would be too costly? Or short to medium cycle runs where you could *re-use* compound for several runs? Lack of floor space for several machines? An Almco custom-designed multi-compartment barrel may give you a cost-saving answer. Automatic forward and reverse. Any combination of compartments and doors.



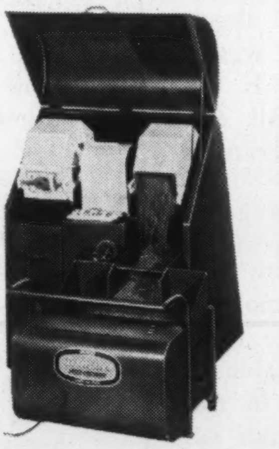
SUB-O-MATIC AUTOMATED SYSTEMS

Almco's exclusive submerged unit is an automatic, "assembly line" system for micro-precision deburring and finishing of small parts in quantity. Saves labor, speeds up processing and flow of high production parts. One man for example can operate this equipment and handle as many as 192 barrel loads per 16 hr. day. Slashes compound expense to minimum because compounds can be re-used for days at a time. These submerged systems can also be obtained in non-automated, straight line systems.



CUSTOM-DESIGNED BARRELS

Almco designs and manufactures special barrels of all types for problems where standard equipment cannot be effectively used. These range from the smallest type to the largest fixture barrel such as the 60" diameter x 60" length barrel shown above. Special large diameter barrels with double flat or triple flat doors are also available to accommodate extra large parts and to allow abrasive media to flow freely over the outer periphery of the part. Your special problems may be solved with one of Almco's custom-designed barrels. Material handling systems can also be closely coordinated with special barrels.



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class, indicate there is no shortage of engineers."

The authors observe that about half of the engineers in this country are college graduates with engineering degrees; about one-tenth are graduates of other college departments; and the rest are without a complete college education. Data presented in the book show that comparative salary levels greatly influence engineering students in selecting the particular branch of engineering in which they will specialize.

Welding Handbook Fourth Edition: Section One. *Edited by Arthur L. Phillips. American Welding Society, New York 18, 1957. Cloth, 6 by 9 in., 500 pp. Price $9.*

The first of five sections to appear over a five year span, the present volume contains information on fundamentals of welding metallurgy, properties of welded joints, thermal and mechanical treatment of weldments, design of welded joints, inspection of welding, mechanical testing of welds, statistical control of weld quality, and safe practices in welding and cutting. Included are a dictionary of welding terms and general engineering tables.

Epoxy Resins: Their Applications and Technology. *Henry Lee. McGraw-Hill Book Co., New York, 1957. Cloth, 6 by 9 in., 316 pp. Price $8.*

How do epoxy resins work? What are their strong and weak points? How can they be used most advantageously for a specific application? The answers to these and other questions provide the reader of this book with enough information on epoxy resins to enable him to better use these plastics materials in many new and old commercial applications.

The full scope of the book is indicated by typical chapter headings: diluents, fillers and resinous modifiers for epoxies; epoxy coatings, adhesives and laminates; plasticizers and flexibilizers; lightweight epoxy foams; casting, potting, encapsulation and sealing of epoxy resins; and curing.

The Making, Shaping and Treating of Steel: 7th Edition. *U. S. Steel Corp., Pittsburgh, Pa., 1957. Cloth, 8 by 11 in., 1070 pp. Price $7.50.*

Completely revised since its sixth edition was issued in 1951, this book offers users of steel a comprehensive summary of present day theory and

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PREVIOUS PROCEDURE

1 Drill bolt holes in "clip angles."

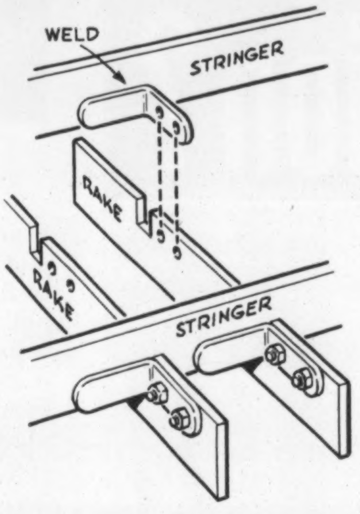
2 Weld clips to stringer.

3 Drill holes in rake blades.

4 Mill stringer slots in rake blades.

5 Bolt rakes to clip angles.

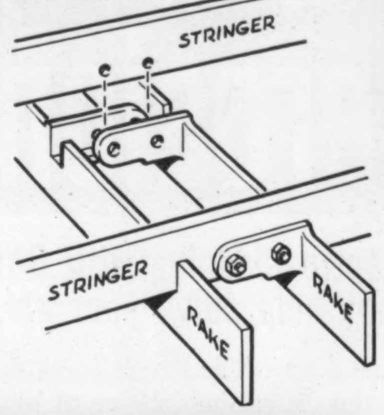
REPEAT FOR EACH BLADE



PRESENT PROCEDURE

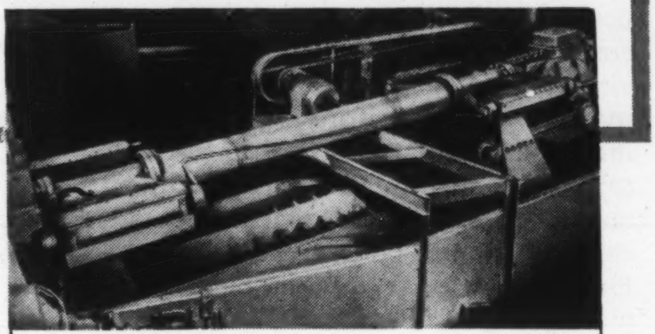
1 Drill bolt holes in stringer.

2 Bolt one-piece castings (complete with holes, slots, and flanges) IN RIGHT- AND LEFT-HAND PAIRS, to stringers.

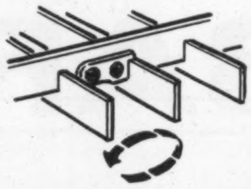


Use of Cooper Alloy close-tolerance shell casting eliminates 3 out of 5 machining operations for Dorr-Oliver rake classifier blades, showing

How to Cut Fabrication Costs with Close-Tolerance Stainless Castings



Type H rake classifier made by Dorr-Oliver Inc., of Stamford, Conn., separates solids in liquid-solid mixtures into two fractions according to particle size. Fine materials overflow with liquid at lower end of inclined tank; larger particles settle to tank bottom, are continuously raked up inclined slope and discharged "over top" Rake blades move in oval track due to motion of rocker head, must be precisely aligned to move settled material up to next rake without either scraping or undue clearance.



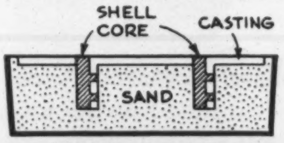
Previous method of attachment of rakes to stringers was by "clip angles" welded to stringers, drilled and bolted to simple flat blades themselves drilled and slotted as shown. Construction was expensive, and often unsatisfactory, in that heat of welding tended to put rakes out of alignment.

In redesigning, Dorr-Oliver decided to eliminate the clip angle as a separate third piece by incorporating it into the blade castings. Original conception was to cast rough slots and holes, then mill and drill them to dimensions. Cooper Alloy, after study of the piece, determined that with close-tolerance plastic shell cores, both bolt holes and stringer slots could be cast directly in the rake blade, without need of further machining. Also, that by using right- and left-hand patterns of rake flanges, *two* rake blades could be bolted to stringers with one set of bolts.

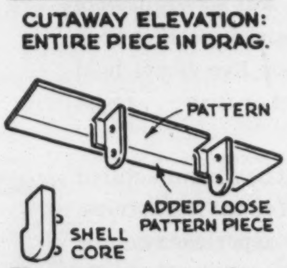
Casting requirements stringent

- Bolted face of each of the upright flanges required a smooth finish (250 A.S.A. Standard).
- 11/16" cored holes had to be smooth, accurate to ±.010", and precisely positioned for proper fitting of parts.
- Stringer slots had to be precisely positioned, accurate in dimensions to ±.025".
- Multiplicity of patterns for different widths of rake blades had to be reduced, for economy.

Casting solutions For the critical flange faces and bolt holes, shell "cake" cores, capable of holding precise dimensions down to ±.010", were prepared. They were inserted and became an integral part of the green-sand molds that formed the less critical outer blade areas.



CUTAWAY ELEVATION: ENTIRE PIECE IN DRAG.



To save cost of a complete new pattern for each rake size, all sizes of rake were designed to have the same blade thickness and flange dimensions. Patterns were then made of the narrowest-width blade in each series, loose pattern pieces being added to increase blade width of the larger rake sizes.

Results –"These rake blades", says Dorr-Oliver, "were used directly as cast, with no additional machining of any kind. Dimensions were precise, surfaces smooth, and finished alignment better than with previous 3-piece welded assembly. New procedure saves time and handling, and has reduced our manufacturing costs on this piece considerably."

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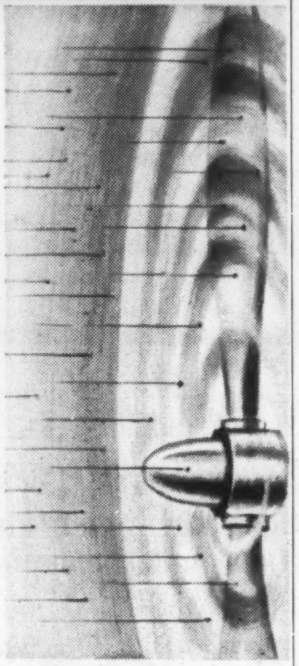

Hamilton Standard Division of United Aircraft Corp. recently made this dramatic test on a twin engined plane. Aluminum prop of one engine was left unplated—the other was nickelplated by Bart Lectro-Clad process. Plane was taxied onto runway covered with loose trap rock. Volley of rock sucked into blades left unplated prop chewed and gouged. The other emerged practically unscathed.

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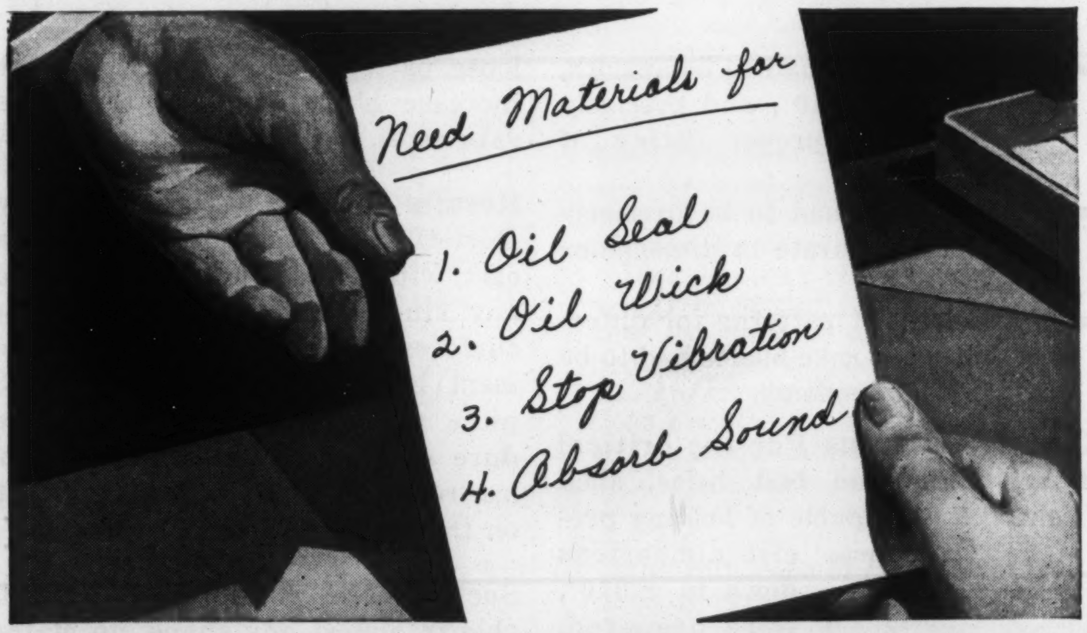

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The book contains 773 illustrations, 126 tables and an extensive index. A bibliography is given at the end of each chapter.

Reports

Titanium-clad steel ROLL CLADDING OF BASE METALS WITH TITANIUM. *P. T. Mataich and F. C. Wagner, Horizons, Inc. Dec. '53. 36 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1 (PB 121479)*

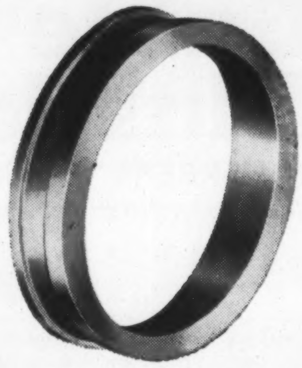
Experiments with roll cladding of titanium to steel show that a good bond is obtained by plating a chromium layer on the steel and pressure welding to titanium. Good bonds were also made by plating successive layers of silver and nickel on titanium before cladding. Elements such as cobalt and nickel formed strong bonds to titanium, but in a very limited temperature range.

Vinyl-coated fabrics WEATHERING RESISTANCE OF FUNGICIDAL VINYL-COATED FABRICS. *J. C. Saylor, Wright Air Development Center. Jan '57. 40 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1 (PB 121913)*

Gives results of outdoor exposure tests conducted on cotton fabrics coated with vinyl formulations containing a fungicide. The fabrics were exposed to four climates and evaluated for breaking and tearing strength, color change and the effects of radiant energy from the sun.

Coatings for titanium CHEMICAL SURFACE TREATMENT OF TITANIUM. *H. A. Pray, P. D. Miller and R. A. Jefferys, Battelle Memorial Institute. May '53. 43 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $1.25 (PB 111805)*

Discusses two antiwear coatings for titanium and its alloys. A sodium



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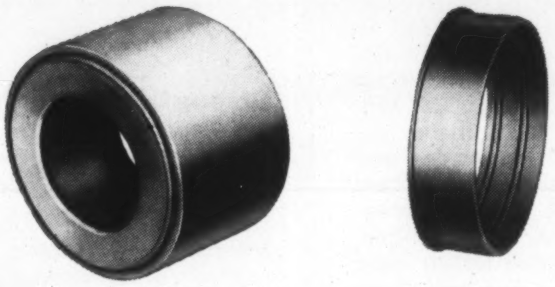

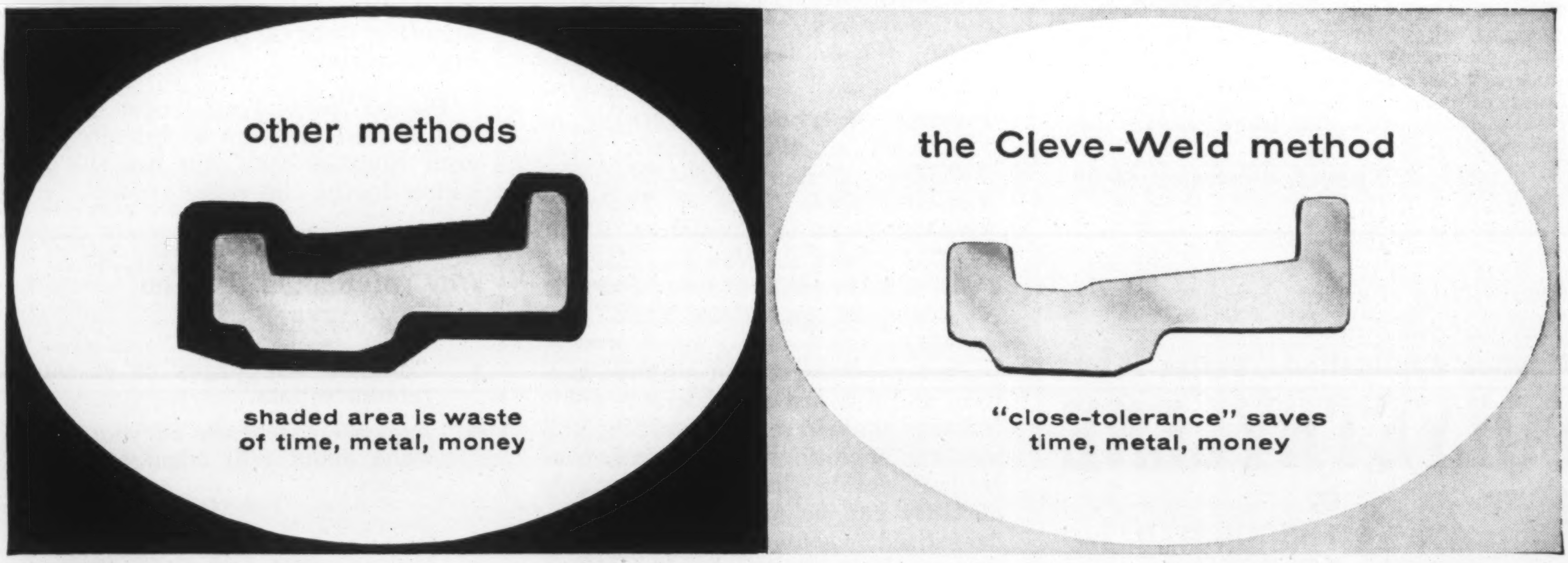
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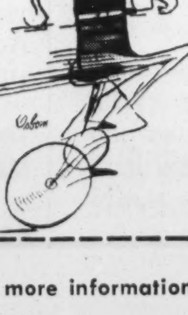

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Strength of adhesives SHEAR STRENGTH AT 75 TO 500 F OF FOURTEEN ADHESIVES USED TO BOND A GLASS-FABRIC-REINFORCED PHENOLIC RESIN LAMINATE TO STEEL. *John R. Davidson, National Advisory Committee for Aeronautics. Dec '56. 21 pp. Available from National Advisory Committee for Aeronautics, 1512 H St., Wash. 25, D.C. (TN 3901)*

Joining molybdenum JOINING OF MOLYBDENUM. *W. N. Platte, Westinghouse Research Laboratories. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D.C.* PART 2. *Nov '55. 130 pp. Price $3.25 (PB 11883)* PART 3. *Nov '56. 85 pp. Price $2.25 (PB 121845)*

Part 2—Research on sintered-vacuum and arc-cast molybdenum welds indicate that if certain welding and material conditions are carefully controlled, joints having appreciable ductility can be made. A titanium-deoxidized vacuum-sintered molybdenum shows better bend ductility than a carbon-deoxidized vacuum-sintered material.

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Fatigue strength EFFECT OF CHANGING CYCLIC MODULUS ON BENDING FATIGUE STRENGTH. *A. A. Blatherwick and B. J. Lazan, Univ. of Minnesota. Oct '56. 129 pp. Available from Office of Technical Services, Dept. of Commerce, Wash. 25, D. C. Price $3.25 (PB 121816)*

Discusses effect on fatigue strength of changes in the cyclic secant modulus, or the ratio of the maximum stress to the maximum strain of the cyclic stress-strain hysteresis loop.

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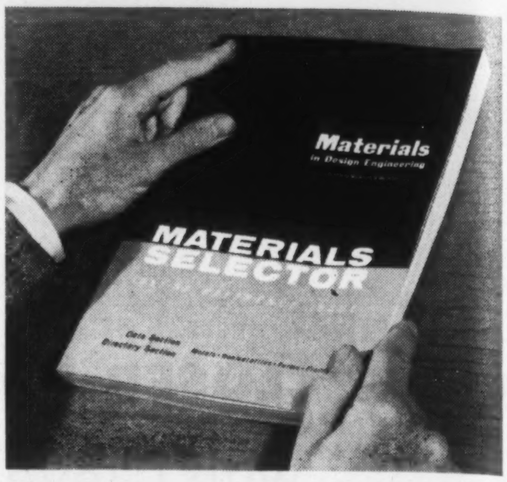

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THE LAST WORD

by H. R. Clauser, *Editor*

Who's Perfect Anyway?

Now that the first *Materials Selector* reference issue is published and in your hands, we editors are trying hard to avoid getting an ulcer or a tic worrying over the errors that surely will be discovered. The issue was hardly off the press before we ourselves found a few (p 13, the modulus of elasticity in tension of cast magnesium is 6,500,000 psi, not 65,000,000 psi; p 8, the specific gravities of molybdenum and uranium are 10.2 and 19 respectively, not 2.2 and 1.91). And we know there will be others. With a data section that contains over 20,000 separate entries of information and data, it would be foolish to expect otherwise.

This particular instance raised in our minds the broader question: Just what degree of accuracy can be reasonably expected of a technical magazine (or of any printed factual material)? There are no standards to which we can refer this question. But in many ways publishing a magazine is like designing and producing any product. Many of the same considerations are involved—people, equipment, materials and economics.

The engineer, in the design of his products, applies a safety factor to compensate for inadvertent errors and occurrences beyond his control. The production man has a control chart that allows him a certain percentage of error. Unfortunately, the editor has no factor or chart to guide him. If he did have a standard—even one that permitted him as little as 1% error—he would be a much happier man, for he would know at least where he stood.

A Writing Style for Engineers

I came across a little book the other day that has more sensible things to say about the art of technical writing in its 140 pages than many books three times the size.

The book is *The Presentation of Technical Information* by Reginald O. Kapp, Dean of the Faculty of Engineering in the University of London. It is distributed in this country by Macmillan Co., New York.

Although I take exception to some of the things author Kapp advocates, this does not detract from the book's over-all excellence. It's a book that assumes a knowledge of the mechanical details of writing (grammar, syntax, outline preparation, etc.), and concentrates on "functional English" style. It describes the distinctive features of technical writing style and shows how facts and ideas can be presented simply, logically and economically.

Let me quote and paraphrase some of the things Kapp has to say in his introductory chapter about the consequences of poor technical writing. He points out that many a good engineer and scientist has an impressive volume of published work, but that it loses much of its value because it is poorly written. "With sublime conceit he (the engineer) thinks himself, perhaps, superior to the obligations of mere craftsmanship; or it has never occurred to him that rather hard work has to be done whenever thought is being transferred from mind to mind; or, if it has occurred to him, he is content to let the reader do the whole of his work . . ."

Kapp goes on to say that the writings of such an author are like quarries rich in ore but hard to work. The engineer-author is saying in effect, "Let those who want the ore dig for it." And often the reader has no choice but to dig. Many of us have spent long, weary hours quarrying in atrociously composed technical papers and articles. The boss often has no other choice, either. He must take the reports of his engineers home with him. "So while he should be recuperating for the next day's task he must quarry instead . . . among a disordered sequence of ideas, clumsy sentences, unfinished arguments, unexplained conclusions, undefined terms, and ambiguous phrases." He, like the rest of us when we are making a literature search, is turned into a quarry slave. The bad engineer-author is our master.